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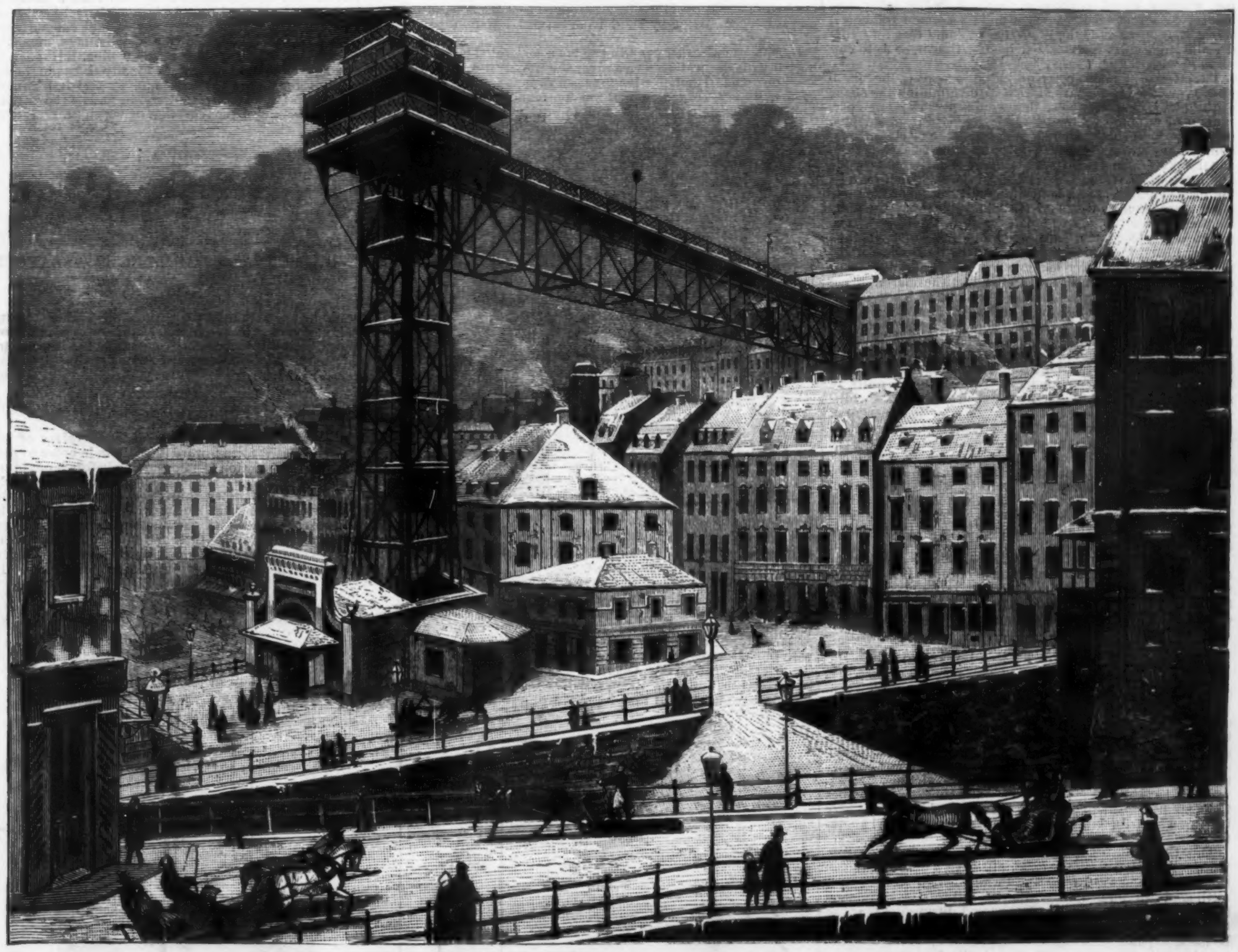
STREET ELEVATOR AT STOCKHOLM.

A PART of the suburb Soedermarlin, of Stockholm, is located on a steep and quite high hill, which is known as Mosebake (Moses' Hill), and from which hill or elevation a beautiful view can be had of the surrounding country, woods, lakes, etc. Elegant gardens have been laid out on the Mosebake, but, as it is very difficult to climb up this steep hill, foreigners and visitors generally neglected to visit this most beautiful part of Stockholm. Capt. Knut Lindmark conceived the idea of erecting a tower in the lower part of the town and connecting the top of the tower with the plateau on the top of the hill by a bridge which, with the tower, was completed March 19, and is now in public use.

The iron bridge, which is provided with four spans, is 490 ft. long. The first column, shown in the annexed cut, taken from the *Illustrirte Zeitung*, is 114 ft. high, and in the same two elevator cars are located, each elevator car being adapted to accommodate about fifteen persons. The elevator cars are raised by means of a steam engine and a hydraulic press at a speed of about 55 in. a second, so that the cars are raised or lowered the entire height of the tower in about half a minute. The lower part of the tower is surrounded by a station, which contains living apartments for the engineer and conductor. On the top of the tower a restaurant, having a double veranda, is built, from which veranda a beautiful view is obtained of those parts of the city surrounding the tower. About 3,000 persons are transported each way daily. Two cents is charged for riding up in the elevator, and about one and a quarter cents for riding down in the same.—*Illustrirte Zeitung.*



THE GREAT STREET ELEVATOR, STOCKHOLM, SWEDEN.

INDELIBLE INK WITHOUT SILVER.—Add caustic alkali to a saturated aqueous solution of cuprous chloride until no further precipitate forms; allow the precipitate to settle, draw off the supernatant liquid with a siphon, and dissolve the hydrated copper oxide in the smallest possible quantity of ammonia. It may be mixed with about six per cent. of gum dextrine for use. Before washing, pass a hot iron over the writing.

TEST-PIECES.

AT a recent meeting of the Institute of Civil Engineers, a paper was read "On the Adoption of Standard Forms of Test-Pieces for Bars and Plates," by Mr. William Hackney, B.Sc.

In breaking test-pieces of the same quality of tough metal by direct tension, very different results were obtained, according to the form of the test-piece employed. The sample that one engineer would define as stretching nearly 44 per cent., before fracture, was classed by another, using a test-piece of different form, as stretching less than 28 per cent. In fact, to obtain from any bar of metal relatively high percentages of ultimate stretching, all that was needed was to use short or thick test-pieces. Mr. J. Barba had shown, in a paper published in the *Memoires de la Societe des Ingenieurs Civils* in 1880, that test-pieces of the same form, namely, in which the ratio of length to diameter was the same, gave the same percentage of ultimate stretching, whatever their size might be; but that in those of equal length but differing in diameter, or of equal diameter but of different lengths, the percentages of ultimate stretching varied very much.

Notwithstanding the extent to which the result obtained in testing a sample of ductile metal was thus affected by the proportions of the test-piece used, no standard dimensions or proportions for such pieces had been generally adopted, and those in common use varied very much. Sir Joseph Withworth, for instance, advocated the use of a test-piece 0·798 in. in diameter by 2 in. long, or 2·51 diameters long, and the test-piece in use at Woolwich Arsenal was 3·75 diameters in length. From these proportions the ratio of length to diameter was increased in the test-pieces adopted by different engineers, especially on the Continent, to 10 or even more. The ultimate stretching of test-pieces cut from the same bar of mild steel, similar in form at the ends of these different proportions, would be:

Ratio of length to diameter.	Ultimate stretching per cent.
2·51	44·5
3·75	37·5
10·00	28·2

The proportions of the strips in which plates and flat bars were tested, had almost as great an influence on the percentages of ultimate stretching as had the proportions of cylindrical test pieces, and those in general use varied nearly as much.

Mr. Barba showed, that in the case of pieces cut by lathe or planing machine from the same bar of metal, the law of similarity, that was the law that test-pieces similar in form gave the same percentage of ultimate extension, whatever their size, was as strictly true in the case of flat as in that of cylindrical test-pieces. The effect on the percentage of stretching of the transverse dimensions of an ordinary strip of plate or flat bar was not so great in the case of a cylindrical test-piece as in the strip; whatever might be the width, the thickness remained always that of the piece of metal tested

Test-strips of mild steel plate, 0·5 in. thick and about 1·4 in. wide, that stretched 27·5 per cent. in a length of 8 in., stretched 37·3 per cent. if the measured portions were only 2 in. long; and in rather harder plates, which stretched 20 per cent. in a length of 8 in., the extension in 6 in. was 25 per cent., and in 4 in. about 32 per cent. The test-strips used at the Crewe Works of the London and North-Western Railway Company were only 2 in. long, and those employed in some tests of boiler plates made at Sheerness Dockyard in 1875, and at Chatham Dockyard in 1879, were 4 in. long; but the length of test-strips adopted for plates, both in this country and abroad, was almost universally 8 in.

The impossibility of comparing the results of tests made by different experimenters of the ultimate stretching of metals, in the absence of standard forms of test-pieces, had long been felt by engineers, and had led to the adoption of several alternative methods of comparing their relative toughnesses.

When a bar of ductile metal was stretched to breaking, it at first extended equally from end to end, with each successive increment of load, until the maximum load that it could carry had been reached, and up to this point the percentage of stretching was absolutely independent of the proportions of the test-piece used. This percentage of extension would thus appear to be the most important in comparing the structural values of metals, and to be that which should be al-

ways the most particularly noted; but practically testing in this way would be more tedious then the ordinary mode of loading the piece until it broke, and then measuring the elongation after fracture; so that in ordinary technical and commercial work, this latter plan would always be preferred.

Another method that had been adopted to a considerable extent, for obtaining comparable measurements of the toughness of metals, without using test-pieces of uniform proportion, had been to measure not the linear stretching, but the percentage of contraction of area at the point of fracture. Practical objections however to this were, that the contraction of area could be much less accurately measured than the increase in length, and that as a tough piece of metal often broke irregularly, it might be difficult to determine what its exact diameter at the point of fracture should be taken to be. Whether on account of the difficulty of accurate measurement, or owing to the percentage of contraction of area not being exactly proportional to that of stretching, it was certain that the results obtained by the two modes of measurement seldom precisely agreed.

A third mode of obtaining comparable results in testing by tension would be to use very long test-pieces, and to reject the percentages of stretching near to the point of fracture; but this would be expensive, and often inconvenient or even impracticable, and would not always give accurate results; for a long bar, when stretched to breaking, often began to draw down simultaneously in several parts of its length. The use of comparatively short test-pieces of some standard forms seemed thus to be the best method of making tests of the quality of bars and plates of ductile metal that could be employed.

The length of 8 in., in the testing of plates, was the only dimension of test-piece that appeared to be generally adopted; and as it was very desirable that the standard forms for cylindrical and for flat test-pieces should be such that the same metal might give the same percentage of stretching, whether tested in the one shape or in the other, this length, with a convenient width and an average thickness, might well be taken as the standard form, and that for cylindrical test-pieces be determined by experiment, so as to correspond with it.

The effect of hammering or rolling in increasing the toughness of metals was so marked, that in determining the shape of the cylindrical test-piece that would give the same percentage of ultimate stretching as the standard form adopted for plates, both shapes should be cut by lathe or planing machine from the same bar, so that one might not be made from metal more drawn down than the other. This increase in the toughness of iron and steel explained the fact, that in testing plates and rivet bars, it was found that metal of the same quality stretched nearly as much in test-pieces of the same length, whether the bars and plates were thick or thin. The use of a test-piece 8 in. long was a more severe trial for a thinner than for a thicker plate; but the toughness of the former had been so much increased by the greater amount of rolling to which it had been subjected, that the one stretched before fracture nearly as much as the other.

As test-pieces similar in form had been found to give the same percentage of ultimate stretching, whatever their size, it might be better to define the standard cylindrical test-piece rather as being of a certain form than of a particular length. This would facilitate the adoption of the same form by engineers of different countries, using different units of measure. In testing plates and bars, such as rivet bars, which were reduced to the size of the test-piece by hammering or rolling, it would be best to retain, as at present, one length of test-piece, whatever the transverse dimensions. In fixing the standard forms, the effect on the percentage of stretching, of the distance from the datum points of the test-pieces of the shoulders or enlargements at the ends by which they were to be fixed in the testing machine, should not be overlooked. The enlargement might begin, for instance, half a diameter beyond each datum point, and its radius of curvature might also be half a diameter.

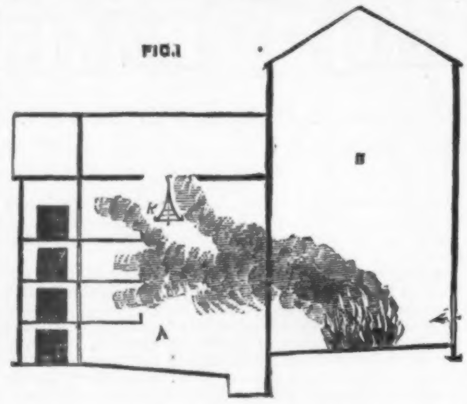
The whole subject of the testing of metals by tension seemed to be well worthy of consideration. If a uniform system of testing could be generally introduced, so that tests made by engineers in all parts of the world might be directly comparable, the advantage would be very great.

PROTECTION FROM FIRES IN THEATERS.

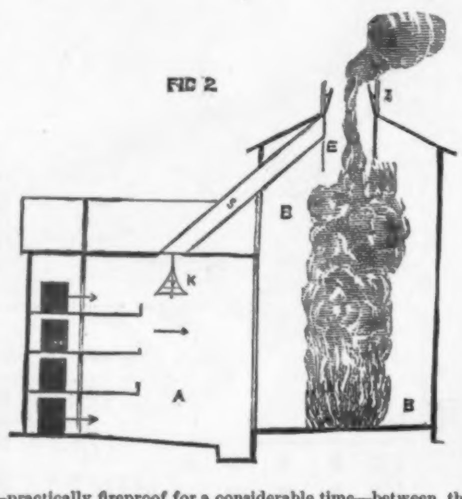
The question of the dangers incurred by theater goers is constantly before the public, but as yet there has been no serious attempt to deal with it. Nor is it probable, until a great disaster has occurred, that sufficiently strong measures, putting an end to the risks which Captain Shaw has clearly pointed out, will be carried into effect. After such a disaster the strong tide of public opinion will render almost any legislation possible—too late, however, for the victims. Meanwhile, it has not perhaps been sufficiently considered whether there are no possible preventive measures which would give increased security without involving serious structural alterations.

The Berlin theaters, most of which are admirably provided with supplementary exits, all have a fireproof screen isolating the stage from the auditorium. This screen comes rattling down immediately after the fall of the curtain on the last act, and is occasionally lowered during the play, so that the audiences become accustomed to it, and would not be liable to panic at its sudden appearance. Fire tell-tales are also in common use. Moreover, all the water service of every theater has to conform to rigid conditions, while half an hour before any performance takes place, a party of semi-military firemen, marched up with as much certainty as the guard at St. James's Palace, takes charge of the whole building.

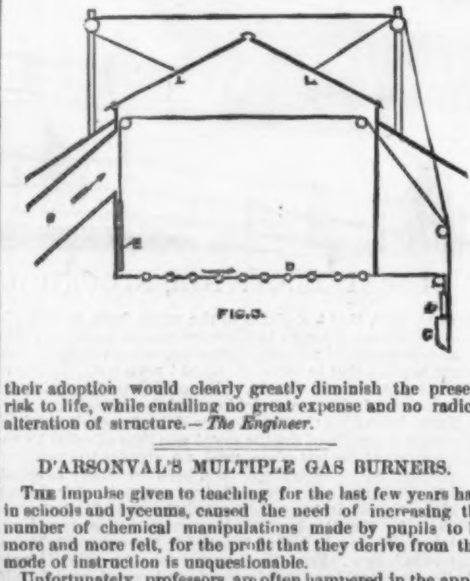
But another plan for lessening the danger has been lately proposed, and is worthy of mention. At the recent Hygiene Exhibition at Berlin—an exhibition which has not received nearly sufficient notice in the English papers—Dr. Obernier, a Bonn professor, received a silver medal for a model illustrating a new mode of preventing the spread of fire in a theater. Dr. Obernier argues that fires almost invariably break out behind the stage; that time only is needed; that the main outlet for ventilation is over the center of the auditorium, and that consequently on the outbreak of fire a strong draught is created from the stage to the auditorium, causing the latter to be enveloped in smoke and flame in a very short time (Fig. 1). The object, then, is to prevent this inrush of hot air and flame. The main outlet, *l*, is placed over the stage, B (Fig. 2), and a ventilating shaft, *s*, is led into it from above the central chandelier, *k*. It is further arranged that the upper outlet of the shaft, *s*, can be closed by a sliding shutter, *e*, while at the same time the area of the opening at *l* can be greatly increased. On the outbreak of fire, therefore, *e* is closed and *l* opened. The result is that a strong draught is created from the auditorium, A, to the stage, B (Fig. 2), and the spread of fire greatly retarded. It is further arranged that this action should be automatic. A chain, D (Fig. 3), passing close under the stage is provided with links of fusible alloy. On the softening of the latter by heat, the weight, U, falls, and adding itself to the weight, G, acts on a system of ropes and pulleys drawing up the sliding shutter, *e*, and opening wide the flaps, L L. By pulling on the weight, G, it can be ascertained at any time whether the arrangement is in working order. The automatic part of the scheme does not appear to be of much value, since it is evidently possible that a considerable fire might have arisen before the fusible links gave way; but it could easily be arranged that the apparatus might be set in action by hand from several different parts of the house.



Dr. Obernier further proposes to lay a perforated pipe connected with the water service over the top of the ordinary stage curtain. The latter having been dropped at the alarm of fire, water is turned on, and the continuous stream serves to keep the curtain drenched and to interpose a wet screen—practically fireproof for a considerable time—between the stage and the escaping audience.



The practical action of the above arrangement was shown in a model before the jurors of the exhibition, and pronounced quite successful, the wet curtain showing great fire-resisting qualities. Experiments of this class cannot, unfortunately, be carried out on a large scale, and when made with models only do not perhaps enforce conviction. But the principles which Dr. Obernier has advanced appear to be perfectly sound, and his proposals are at least worth the serious consideration of the proprietors of our theaters, since their adoption would clearly greatly diminish the present risk to life, while entailing no great expense and no radical alteration of structure.—*The Engineer.*



D'ARSONVAL'S MULTIPLE GAS BURNERS.

The impulse given to teaching for the last few years has, in schools and lyceums, caused the need of increasing the number of chemical manipulations made by pupils to be more and more felt, for the profit that they derive from this mode of instruction is unquestionable.

Unfortunately, professors are often hampered in the application of their programme by the sparseness of the funds that are allowed them, and the acquisition of a large number of the same apparatus and utensils is often impossible. Mr. D'Arsonval, the learned professor of the College of France, who has already rendered so many services to chemists and physicists by the ingenious arrangement of the apparatus he has devised, has just surmounted a portion of such difficulties as regard apparatus for heating by gas in laboratories.

The multiple gas burner figured herewith is designed to act as a cheap substitute for the Bunsen burner of laboratories, the evaporating furnace, the oxyhydrogen blow-pipe, capsule-supports, etc., etc. The principal part of the multiple burner consists of a cast iron base which carries a horizontal copper tube, A (Fig. 1), with a regulating air cock, and to which may be adapted in turn all the other tubes. If it be desired to have Mr. Berthold's modifications of the Bunsen burner, the tube, C, is placed upon the tube, A, over which it slides by friction until it reaches a stop. In order to have an evaporating furnace, it is only necessary to substitute the hollow ring, E, for the tube, C. The grate for organic analyses is formed of two ordinary bricks placed parallel with one another and connected by two arched pieces of iron that support the analyzing tube, which is likewise of iron (Fig. 2). The whole is heated by a long copper tube, D, containing apertures, which is, like the others, mounted upon the tube, A. The oxyhydrogen blow pipe, B (Fig. 1), is likewise adapted to this same tube, A. Finally, the stand shown in Fig. 2 has for its base a large plate of cast iron which serves as a table for the entire apparatus, and its rod carries a ring and a clamp for the reception of capsules, receivers, retorts, etc.

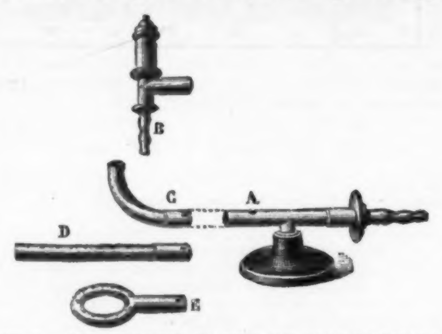


Fig. 1.—DIFFERENT PARTS OF D'ARSONVAL'S GAS BURNER.

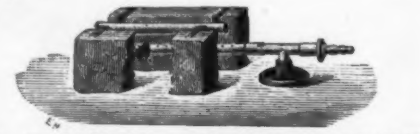
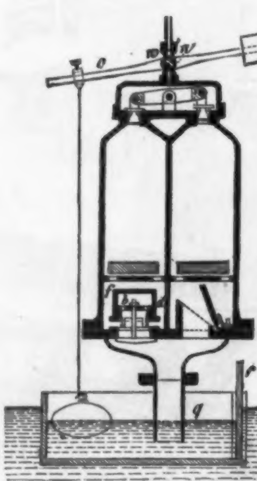


Fig. 2.—D'ARSONVAL'S GAS BURNER ARRANGED FOR ORGANIC ANALYSES.

It should be added that all the parts of this burner are very practical, and give at least the same temperatures as we are accustomed to find in laboratory apparatus for heating by gas, while at the same time costing four or five times less than these.—*La Nature.*

VOGEL'S VALVES FOR PULSOMETERS.

Mr. Vogel, of Bochum, gives the balance valves of his pulsometer a pointed form toward the bottom in order to prevent the change of motion from occurring before it ought to, a thing that easily happens in pulsometers that are operating under a full charge of water, as an effect of the impact of the sucked up water against the steam distributing valves. In order to prevent a shock of the suction valves, Mr. Vogel gives these a special form. Over the suction aperture there is fixed a perforated piston, *b*, upon which moves a cylinder, *d*, closed above, and which performs the role of a valve. In addition to this, a horizontal partition containing apertures, *f*, is placed over the suction valve and just beneath the force pipe.



VOGEL'S VALVE FOR PULSOMETERS.

These two arrangements act as follows: A notable quantity of the water sucked up strikes, during the period of suction, against the fixed piston, *b*, thus preventing a direct shock from occurring against the valve, *d*. The lifting of the latter, then, takes place only in measure as the water can rise above the piston through the small apertures therein. The result is an arrest or a moderation in the rise of the valve. As, moreover, the sections of the apertures, *f*, are smaller than the largest total open surface of the valve, *d*, the quantities of water that enter the chamber at the time the valve rises are greater than those that make their exit at *f*, and this brings about an increase in the pressure over the valve. When, finally, the pressure in the chamber becomes sufficient to balance the force that tends to raise the valve, the cover, *d*, stops at a definite height without being held by the limit of the travel. Such are, at least, the effects that the inventor thinks that he obtains.

A third means of distribution adopted by Mr. Vogel presents some advantages, without any doubt. In addition to the principal way, the steam stop cock, *ss*, is provided with a small lateral aperture, *n*, which puts the pump chambers in communication with the atmosphere, when the steam is shut off. The water is thus prevented from being sucked up into the valve boxes when the pulsometer is set running. If the key of the cock be connected with a lever and float, *o*, the admission of steam can be regulated automatically, according to the level that the water is occupying at every instant in the suction reservoir. When the level rises, the steam cock opens wider, and the effect of this is to prolong the travel, and inversely. When it is desired to lift from a source only a certain quantity of water, there is allowed to flow into the reservoir, *q*, an amount of the liquid that is regulated by a slide valve, *r*.—*Dingler's Polytech Jour.*

[Continued from SUPPLEMENT No. 433, page 6907.]

SUBMARINE EXPLORATIONS.

HAVING described the sounding apparatus used on board of the Talisman, it now remains for us to speak of the wire employed and of the arrangement of the sounding lead.

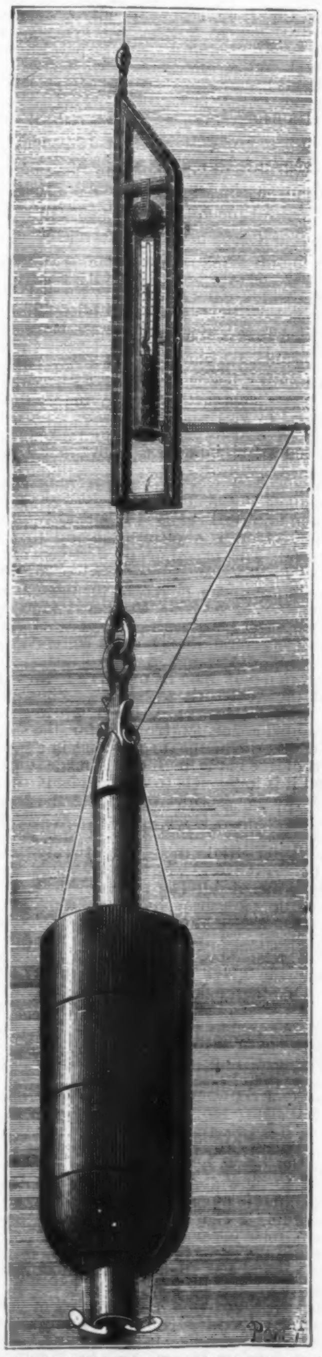


FIG. 1.—SOUNDING LEAD OF THE TALISMAN.

The wire was of steel, and of the kind commonly called *piano cord*. Its diameter was about 1 millimeter, and its resistance will seem surprising when it is stated that with this small size it was found capable of supporting, without breaking, a load of 140 kilogrammes. But its small dimensions and its great resistance did not constitute its sole qualities, for its surface, when unwound, being small, it possessed the further advantage of offering very little resistance to the water, and consequently of being incapable of being drawn along by currents. It is now known that when hemp cords were formerly used for making soundings, the results that were obtained when great depths were concerned were often very inaccurate. The errors were due to the fact that as the line used had to be of sufficient diameter to support the weight of the lead, the surface that it offered to the action of the currents became so great that the latter were enabled to carry it along and cause it to deviate. In spite of the absence of currents, soundings made with a line were still apt to fail in accuracy, for it frequently happened that the line, on unwinding through its own weight, formed an entangled mass above the lead. By the use of steel wire the action of the currents is overcome, and gravity has no longer to be thought of.

The use of a thin wire capable of carrying a very heavy weight marks a clear case of progress in deep soundings. Thanks to it, we know positively now that the depths of thirty, forty, and fifty thousand feet shown by certain soundings do not exist. Thus, in the North Atlantic, where soundings made by the line had shown twelve thousand meters, those made by the steel wire showed that the depth was but six thousand. During the cruise of the Talisman several errors of this kind were remarked, two of the most important of which we shall point out. On the 6th of August, in lat. 27° 10' and long. 42°, where the charts showed old soundings of 1,000 to 2,000 meters made by the line, 4,965 meters were found. The next day, in lat. 30° 17' 30" and long. 43° 17', bottom was found at a depth of 3,520 meters instead of 2,000.

Ten thousand meters of steel wire were wound upon the drum of the Thibaudier apparatus. The free extremity of the wire was connected with a portion of hemp cable, one meter in length, that supported the sounding tube at its lower extremity. This latter apparatus, which is represented in Fig. 1, consists of a long thick iron tube, with cylindrical extremities. It may be considered as consisting of two superposed chambers entirely independent of each other. In the upper one of these is inclosed a metallic rod that terminates in a ring to which is attached the hempen cord that is affixed to the sounding wire. When a traction is exerted upon this ring the rod partially disengages itself, its travel being limited to a certain extent by a stop. Into the right and left sides of this rod teeth are cut. When it is desired to use the apparatus it must be given sufficient weight not only to bring about its descent, but also to quicken its travel within certain limits. In order to effect these two objects, it is loaded with weights that consist of large iron disks having an aperture in the center. The external surface of these disks is traversed by two deep grooves in the direction of two contrary generatrices. The body of the sounding apparatus is passed through the orifice in the disks, the number of which varies according to the depths that it is supposed will have to be reached. These weights are fixed by means of a wire provided with three rings—one in the center and one at each extremity. The middle ring is introduced around the sounding tube through its lower extremity, and runs to the lower surface of the last weight. The two wires are then placed upon the right and left sides, and are made to enter the grooves that we have said existed upon the lateral surfaces of the disks. After this the rings with which the wires terminate are hooked on to the two teeth of the rod which projects from the upper part of the apparatus. This arrangement is shown in Fig. 1. During the whole time of its descent to the ocean bottom, the toothed rod, from which are suspended the weights, remains disengaged as a consequence of the resistance offered by the unwinding of the wire to the traction of the sounding lead. When the bottom is reached the resistance offered by the unwinding of the wire ceases, and the weights then pull upon the rod to which they are hooked and cause it to enter the body of the apparatus. In this act, the rings of the wire that support the weights are lifted and unhooked as a consequence of the collision of the tube that the rod enters. The cast iron disks, being thus freed, at once fall, and the sounding tube, being relieved of a considerable weight, can be quickly drawn up on board.

When submarine explorations are being made, the sole object of sounding is not to ascertain the depth of the sea at a certain point, but it must likewise furnish information in regard to the nature of the bottom that has been reached. With this end in view, the lower part of the sounding tube is arranged in a special manner, its aperture being provided with two clacks that open upward and that are kept lifted by a wire during the entire time of descent. These clacks, each of which is provided with a peculiar movement, close when the cast iron disks become detached, since the latter, in leaving the apparatus, rest upon their levers and thus bring them together. When the lead has reached bottom, and the latter is not very resistant, it always enters quite deeply. Consequently, the lower part of the tube, which at this moment is open, becomes filled with a certain quantity of mud or slime, which is at once imprisoned through the closing of the orifice that succeeds the sudden fall of the weights. Each of the valve levers is hollowed out in the shape of a spoon, whose bowl is filled with tallow. The object of this arrangement is to permit of bringing to the surface specimens of rocky, sandy, and gravelly bottoms, and it thus greatly adds to the functions of the sounding tube, which is only capable of furnishing information in regard to such bottoms as are sufficiently soft to allow it to penetrate them. The depth and the nature of the bottom having been determined, it remains to learn the temperature of the water at the point that the lead has reached.

The thermometers that have been used for this kind of research are extremely strong, for they have to undergo pressures of over three hundred atmospheres, that is to say, such as exceed three tons, over a surface of one square decimeter. They are formed of two cases of very thick glass. It would be impossible to use ordinary maximum and minimum ther-

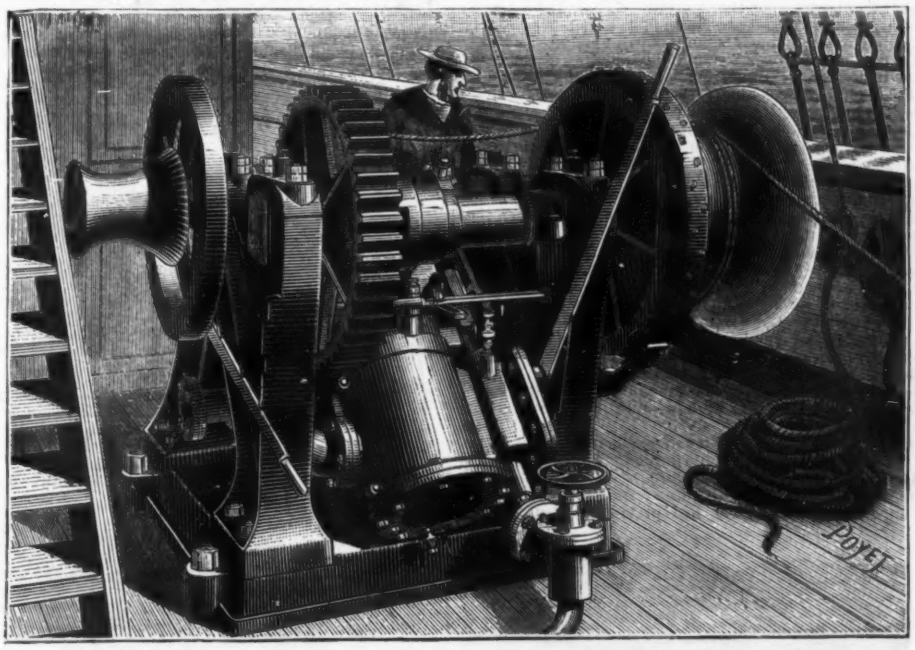


FIG. 2.—WINDLASS FOR RAISING AND LOWERING THE DREDGES.

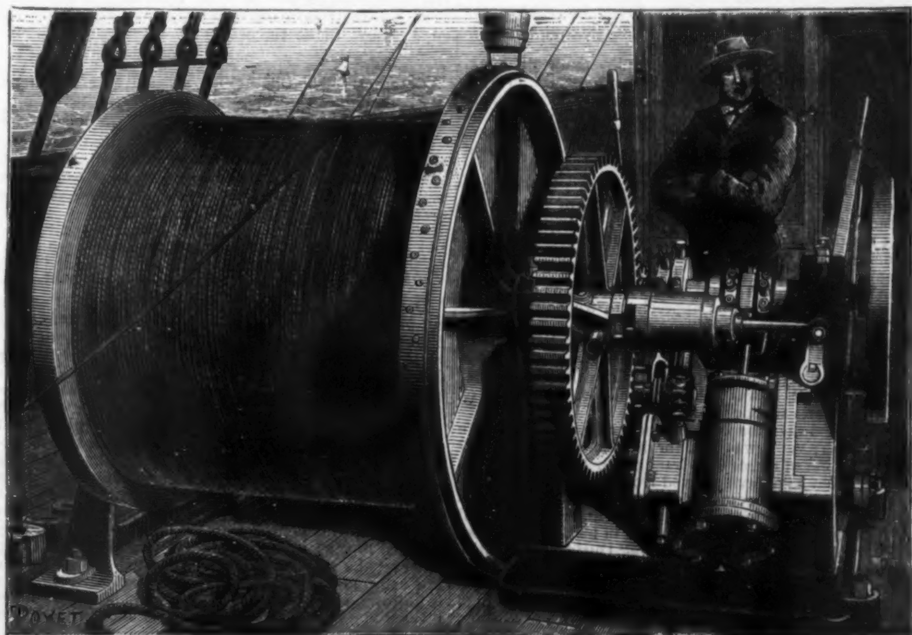
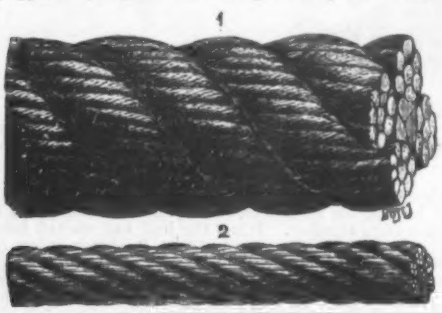


FIG. 3.—WINDLASS FOR WINDING UP THE STEEL CABLE.

mometers, since we could not be sure of having the temperature of the bottom, as the thermometers would very probably show the variable temperatures of the strata through which they had passed. The instruments employed on the Talisman possessed a mechanism such that the metallic tube in which they were inclosed could be turned over at a given moment. The column of mercury then broke at a point situated above the reservoir, where the tube presented a contraction. The result was that the mercury contained in the tube flowed into the lower end, which was graduated. When the thermometer was raised up on board, it could thus be exactly ascertained what the temperature was at the moment the thermometer was turned over. In Fig. 1 we show one of these thermometers (constructed according to directions of Mr. Milne Edwards) in the position that it occupies at the moment at which it is being lowered into the sea. It will be seen that it is made fast to the cord that connects the wire with the lead, and that it is inclosed in a protecting tube of metal. This tube, perforated with numerous orifices, and supported by a metallic frame, is held in a vertical position by a hook whose very long tail projects transversely. The extremity of this tail is attached to the weights of the apparatus by a hempen thread. When these weights detach themselves they pull, through the intermedium of the thread, upon the extremity of the tail of the hook, and this, yielding to their traction, falls. The metallic tube being thus freed, becomes submitted to the action of a spring that causes it to tip over, so that the bulb of the thermometer comes to occupy the upper portion of the apparatus. As for the hempen thread, that is so fragile that it soon snaps under the increasing traction that it undergoes.

The results obtained with these thermometers were very satisfactory, and much superior to those given by apparatus constructed after a different plan. Messrs. Negretti and Zambra endeavored to bring about the reversal of the tube containing the thermometer by means of a helix fixed to the apparatus, and that had an arrangement of blades such that it could only revolve during the descent. The disengagement occurred after a certain number of revolutions. Mr. Magnaghi slightly modified this arrangement in such a way that the disengagement was effected only after a certain definite number of revolutions of the screw. During the course of the experiments made on the Travailleur these thermometers were employed, and it was observed that the helix very often did not move, either because it had not sufficient play or because the sounding tube was raised a little too gently. With the apparatus devised by Mr. Edwards, and arranged as we have indicated, the overturning is always effected perfectly.

During the cruise of the Travailleur the means for operating put at its disposal were quite limited. All the machinery had been furnished by the Rochefort arsenal, and an endeavor was made to utilize, for letting down and raising the exploring apparatus, engines that had previously been built for



1. Hemp cable. 2. Steel cable.

Fig. 4.—SOUNDING CABLES (ACTUAL SIZE).

another purpose entirely. So it was not surprising when they were placed on board to see that the rapidity and safety of their running left much to be desired. Pursuant to orders from the Minister of the Marine, there were put on board the vessel this year special engines which were much more powerful than those that the commission had thereto had at its disposal. In Figs. 2 and 3 we represent the two windlasses that were employed for lowering and raising the dredges or nets. These two machines, one of 10 and the other of 25 H.P., were built in the shops of Mr. Leblanc under the supervision of Mr. Godron, an engineer of the Navy. They are of the same type as those that were employed by Mr. Agassiz during the submarine exploration that he made on the Blake in the Sea of the Antilles. One of these windlasses (Fig. 2) was employed for raising the dredges, while the other (Fig. 3) served to wind up the cable over its large cast iron drum.

For dredging purposes there was employed on the Travailleur a hemp rope, which is shown of actual size in Fig. 4. This rope not only possessed the inconvenience of being of large size, and consequently of being very cumbersome, but it also had the defect of offering only quite a limited resistance, since it was incapable of supporting a load of more than 2,000 kilogrammes without breaking.

On board the Talisman the hemp rope was replaced by a steel wire cable (Fig. 4) formed of six strands of seven steel wires each twisted around a hemp core. Notwithstanding the fact that it was composed of 42 different wires, it was only one centimeter in diameter, and its size was therefore much smaller than was that of the hemp rope. In order that the relative proportions of the cables used on the Travailleur and Talisman may be appreciated, we figure a portion of each of them in Fig. 4.

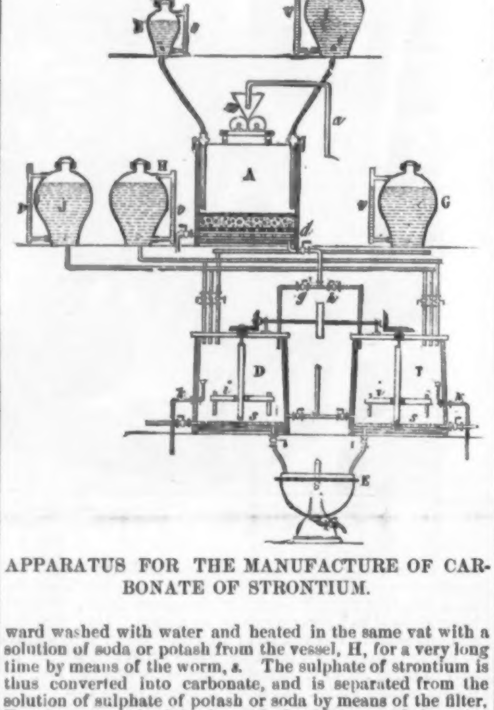
Notwithstanding the fact that the diameter was less than that of the hempen rope, the resistance of the steel cable was double that of the latter, since, in the experiments that were made with it, it was found to support a traction of 4,500 kilogrammes without breaking.

It would seem that the cost of such a cable must have been very high; yet it was not, for it amounted to but 1·7 francs per kilogramme, or 0·62 franc per meter. As regards the services that have been derived from the application of this cable, when it concerned the dragging of the dredges and nets at a depth of more than five thousand meters, I will recall what Mr. Edwards said about it in his lecture before the Geographical Society of Paris: "During the entire cruise this cable never ceased to excite our admiration, and, thanks to it, everything was simplified. There was no obstruction, no fear of breaking. It had the strength to hold the ship like an anchor chain, and it was capable of kinking and afterward of straightening itself out again without perceptibly losing its resistant qualities. At times its extremity became entangled over a length of several hundred meters, and came on board in an almost inextricable state of confusion; but, when we had succeeded in disentangling its numerous knots, the strength of the cable was found to be unaffected.—*H. Filhol, in La Nature.*

APPARATUS FOR THE MANUFACTURE OF CARBONATE OF STRONTIUM.

With a view of extracting, under the form of carbonate of strontium, the strontia contained in the residue obtained when calcined strontia is slaked in order to manufacture crystals of caustic strontia, Messrs. Sidersky & Probst, at Rositz, employ the apparatus shown in the accompanying cut.

The residuum is put into a vessel, A, through a wide tube, *a*, which is provided with a device for holding back stones. Before entering this vessel it is divided by two cylinders, *w*, in which it is made to boil for a few minutes with hydrochloric acid coming from the vessel, C. This latter is provided with a level indicator, *v*. The dissolving of the strontia is quickened by causing steam to enter the worm, *d*. The acid solution, filtered by the layer of gravel, *e*, placed between two perforated bottoms, flows according to the position of the cocks, *g* and *h*, into the vats, D or T, that contain agitators, *i*. There is then added to the solution sulphuric acid from the vessel, G. The precipitated sulphate of strontia deposits, and the liquid may then be easily removed by means of the revolving siphon, *k*. The precipitate is after-



APPARATUS FOR THE MANUFACTURE OF CARBONATE OF STRONTIUM.

ward washed with water and heated in the same vat with a solution of soda or potash from the vessel, H, for a very long time by means of the worm, *s*. The sulphate of strontium is thus converted into carbonate, and is separated from the solution of sulphate of potash or soda by means of the filter, E. An excess of sulphuric acid should be avoided, as this would form sulphate of lime. If, however, this should form through inadvertence, a hot solution of sulphate of ammonia is introduced from the vessel, J, and this dissolves the sulphate of lime. If the solution contains iron, the latter is precipitated by means of ammonia from the vessel, F.—*Dingler's Polytech. Journal.*

A GOOD INTENSIFIER FOR GELATINE PLATES.

In 1856 I saw (using the language of those days) a positive converted into a negative by bichloride of mercury, iodide of potassium, and ammonia, and only a few days ago it was taken out of the paper in which it had lain for eight-and-twenty years, and yielded a print quite as good as those first obtained. Several of the published methods of mercurial intensification may be relied upon as both safe and practical; but the following, which has been repeatedly described, I believe to be the best:

A.

Mercury bichloride	1 ounce.
Ammonium chloride	1 "
Potassium iodide	quant. suff.

Dissolve the mercury and ammonium salts in ten ounces of water, putting them both in together, and add sufficient of a strong solution of potassium iodide to dissolve the red mercury iodide formed by the first additions. Then make up the bulk with water to twenty ounces.

B.

Silver nitrate	½ ounce.
Potassium cyanide	quant. suff.

Dissolve the silver in five ounces of water and add sufficient of a strong solution of the cyanide to dissolve the precipitate formed by the first additions, and make up the bulk with water to twenty ounces. The solutions will keep indefinitely, and where very much intensification is required should be used at the full strength; but when only a slight action is desired, A may be diluted to one-half or one-third.

The fixed and well-washed negative should be placed in a dish with sufficient of A to cover it, and kept in motion for a few seconds. Let the action proceed, examining the plate from time to time, till apparently sufficient—or, rather, a little more—density is produced. At this stage the negative will have the appearance of a rather dense but thoroughly good printing collodion image, and the operator may feel inclined to "let well alone." On well washing the plate, however, he will find the whole deposit has assumed a yellow color, and the washing must be continued till that color is uniform all over. When that change has been accomplished the plate must be placed in another dish, covered with B, and kept in motion for a few seconds as before. Gradually, beginning with the higher lights, the yellow will give place to a fine olive brown, and the action must be allowed to continue till the whole negative has assumed that color. A final wash completes the operation, and I have little doubt that whoever will give it a fair trial will no longer feel that there is any difficulty in intensifying his negatives.

Regarding the practical permanence of the image thus intensified, I have no doubt whatever. I have practiced the matter pretty constantly during the last two years and there lies before me while I write a negative of the birthplace of the late Dr. Moffat, from which some hundreds of prints have been taken, and it is, so far as it is possible to judge, absolutely unchanged.—*John Nicol, Ph.D., in Br. Jour. of Photography.*

RAMIE—A RECENT INDUSTRY.

This article contains the principal facts and statements contained in a paper entitled "La Ramie," published in the *Revue Scientifique*, which is of unusual interest, and may assume more importance in the future. The paper is by Gaston Sencier.

The *Ramium majus* is the Chinese nettle, which for some time past has attracted the attention of textile manufacturers as affording a serviceable fiber for commercial and industrial purposes. The weaving of the fibers of nettles is practiced in China, Japan, and in all the countries of the extreme Orient, and has been known there since the earliest days. The importation of these fibers into Europe appears to extend back to the 16th century, but it is only since 1840 that the English have received in appreciable quantities from India and China the textile fibers of nettles, under the name of *rhea* or *China-grass*. These ribbons are the bark of the plant, in which are found the fibers agglutinated together by a gummy substance. The plant stems are cut in China when moist with the morning dew; the bark is cut throughout its entire length, and torn off. The bark is scraped to free it from a light brown pellicle or skin which covers it.

Many sorts of nettles are used by the Chinese; the species referred to in this paper, is the *Ramium majus*, afterward called *Urtica tenacissima*, and later *Urtica utilis*.

The first attempt to use this fiber in Europe for spinning dates from 1814, when Dr. Buchanan, director of the Garden of Acclimatation at Calcutta, sent some parcels to London. The thread has three times the resistance of hemp. Many obstacles interfered with the further development of this industry just then, but it slowly strengthened, and in 1851 some very remarkable specimens of thread and woven fabrics were exhibited by English firms.

Attempts were then instituted to raise these plants in France, Corsica, Italy, Mexico, Cuba, and Louisiana, but they were poorly executed.

There are several species of textile nettles, each one of which demands different conditions of climate and soil. They planted in warm regions, in the middle of France, the *Urtica nivea*, which is a plant belonging to temperate or cold climates. The experiments were generally fruitless, and the rising enthusiasm encountered a summary check.

During the American civil war the price of cotton rose, and the question of reviving the nettle industry again assumed importance. Many articles appeared, the chambers of commerce in several French cities started investigations, and the Minister of Commerce and Agriculture appointed a commission to report upon its use. The Franco-German war stopped all these enterprises.

At the same time in 1870, the English government of India instituted a competitive prize for the best machine that would decorticate the nettle stems in a green state, as the harvest of the nettle in India is made during the wet season, and it is impossible to dry the plants afterward.

The prize was not awarded, though Messrs. D. and I. Greig received a premium of laudation; and a new contest was instituted in 1880.

At this latter trial there were twenty-three contestants, but only seven machines were presented, and again the prize was not awarded. The cause of these failures lay in the terms of the requisition made by the commission, which required the machine first to separate the woody parts of the stems from their envelope, then to clean the barks thus obtained of their brown coating and the gummy matter which pastes the fibers together, and finally to produce a thread not costing more than £45 sterling for 1,000 kilogrammes (2,200 lb.) delivered in London, the cost of extraction to be equal to or less than £15 sterling per 1,000 kilogrammes (2,200 lb.).

This complicated programme made the machines intricate and scarcely practical.

The *ramie*, or nettle of China, bears some resemblance to hemp at first sight; but instead of being an annual with a single stem, it is an active plant which shoots out each year new scapes thickly. Its roots bury themselves in the ground as deep as 80 cm. (2⅝ ft.), and its stems attain a height of 2 meters (6·5 ft.), according to the climate and care of cultivation. The number of cuttings made each year varies from 2 to 6, according to climate; the duration of the plants, it is said, lasts in some instances 100 years.

To cultivate the *ramie* in the best conditions, it is necessary to have a light soil, slightly sandy, but rich, moist, or easily irrigated. Marshy land should, however, be avoided, as the roots are rotted by it. The neglect of this precaution has brought ruin upon several promising plantations. Strong and compact soils are scarcely less favorable. The woody part develops in such soils too vigorously, and the utilizable bark or cuticle is proportionately diminished.

The plant is propagated by seed, buds, or shoots, or by fragments of the roots. The last method is solely employed in the extreme Orient; it is the most convenient, and should be the only one used. The plants are placed apart from each other 50 cm (1⅝ ft.) on all sides. The following year, after the first growth, when the young plants are strong enough to resist the encroachments of weeds, one out of every two is torn up, and the roots again subdivided and planted afresh.

It is only necessary to irrigate during the very great heats, when it is best effected by lines of furrows or ditches between the plants. The labor of cultivation is confined during the first year to hoeing; later the irrigating ditches are cleaned only.

The stems are harvested just before the flowering of the plant, at the moment when the lower part assumes a brown tint. The leaves can be used for fodder or as paper pulp. It is said that there is a silk worm which feeds upon the leaves. As to the stems, some authorities say it is necessary to decorticate them in the green state, except under such exceptional climatic conditions where it is possible to dry them, inasmuch as this drying is very difficult to effect, and as in the green state the nettle is not preserved, but decomposes and moulds rapidly. Other authors recommend decortication in a dry state.

M. Hardy, director of the experimental garden in Algiers, calculates to make two cuttings a year on plants 2 meters (6·5 ft.) high, each cutting giving per acre 60,000 kilogrammes (132,000 lb.) of green stems. Subtracting 25,500 kilogrammes (56,100 lb.) of leaves from this weight leaves 34,500 kilos. (75,900 lb.) of stems, which finally yield 1,750 kilos., or for two cuttings 3,500 kilos. (7,700 lb.), per acre of fiber.

From these indications the cultivation of the Chinese nettle appears to be remunerative, but, in fact, the development of this industry depends entirely upon the invention of a simple and inexpensive process of decortication.

The first attempts to treat the nettle in Europe and Algiers have naturally followed the process employed with flax, *i. e.*, maceration in water. But this produces a decomposition of the gummy matter which incloses the fibers, a material formed of pectose or analogous substances. This gum separated, it is only necessary to separate by combing the textile bark from the woody interior. This is simple for the flax and the hemp, in which the gummy matter is relatively inconsiderable, and whose stems, at the time of harvesting, are of the same size and maturity. The maceration, on the other hand, does not succeed with the nettle, whose state varies from one part of the stem to another.

The Malays and Chinese seem to have renounced maceration, though it is practiced in a limited way in China, Borneo, and Sumatra. The experiments of maceration made in Algiers by M. Moerman and other inventors have not given the best results. M. Moerman operated at a temperature of 25 deg. Cent. after the addition of sulphur, coal dust, chalk, and other ingredients. At the end of some days of this treatment, the stems were heavily crushed between rollers, then passed into a second machine formed of two pairs of large rollers, revolving at different rates of speed, in order to bruise the stems and break the woody tissues which another machine subsequently removed. This was ingenious but unsuccessful.

Several machines more or less successful are described, which treat the dry plant, of which that of M. P. A. Favier has pre-eminence.

The first machine constructed by M. P. A. Favier, in 1880, was composed of a jaw through which passed the stems of the nettle. This jaw carried a sharp knife edge, which cut the nettle throughout its entire length, and was followed by a sort of prow widening this slit. The stem thus opened was broken by plates, which flattened it, and, crushing the pectic matters which glued the bark to the wood, freed the bark entirely. The stem then appeared as two ribbons, one of wood and one of bark, superimposed but not adherent. A crusher broke the wood and expelled it. The bark then passed between corrugated drums, which lightly rubbing it freed it of its brown pellicle.

This machine, still further improved by him, is said to require only ½ horse power to run, and with two feeders decorticates 50 stems per minute or 540 kilos. (1,188 lb.) of dry stems in a day of twelve hours.

The machines for treating it in the green state have not been very useful, though that of L. and D. Greig is the best, except that it does not extract all the fiber.

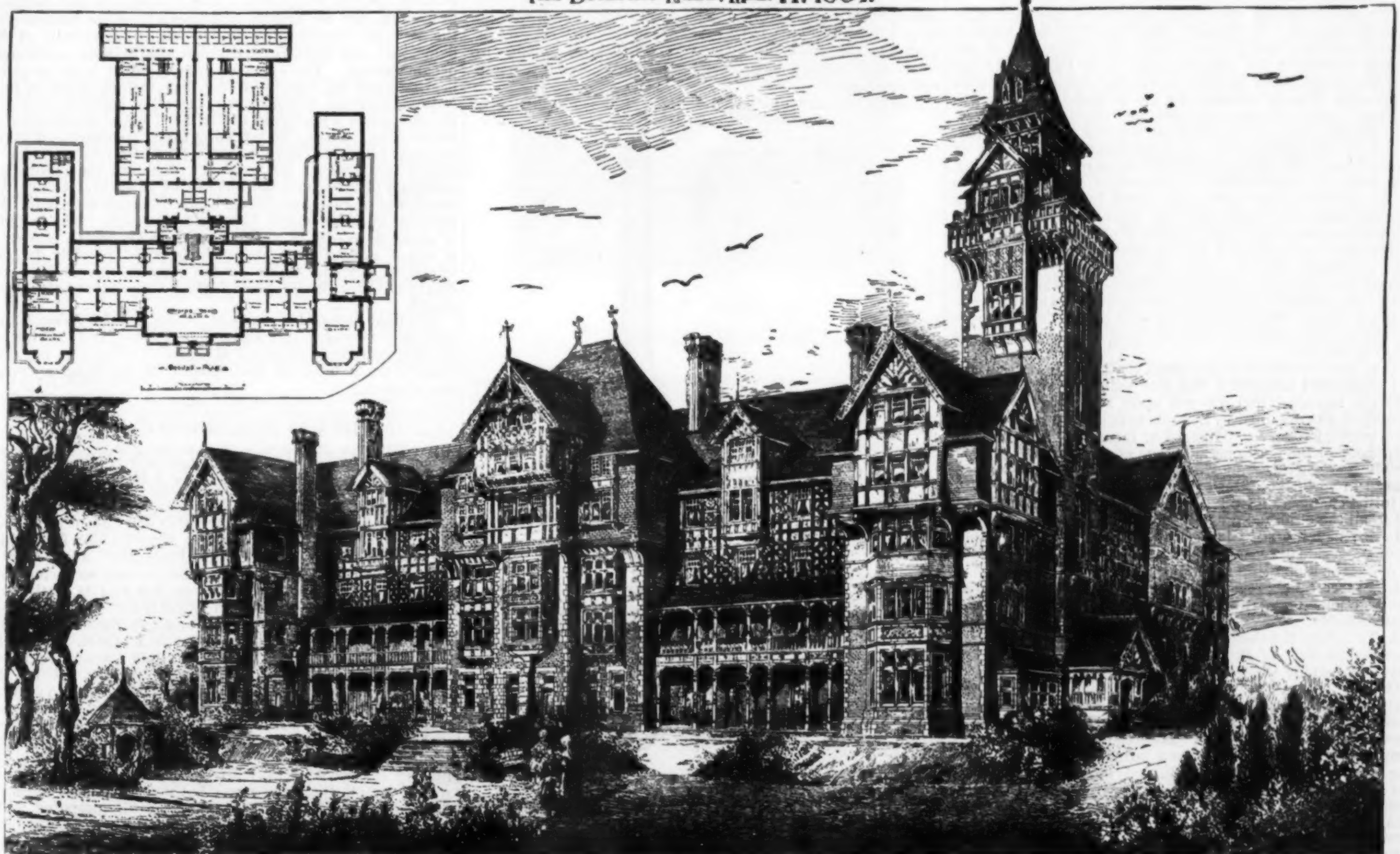
M. A. Favier submitted some stems of the nettle to heat in a closed vessel, and saw that after a similar treatment the bark separated easily from the woody interior without loss of fiber or the slightest retention of woody particles. M. Favier devised a process of decortication by which the nettle stems are placed in wooden boxes, closed, into which steam or hot air is injected. The duration of their exposure varies according as the stems are more or less freshly gathered. After this treatment they are easily barked by hand, which is done by children.

Other inventors in the United States and in Europe are endeavoring to secure decortication by simply macerating the stems in a warm alkaline solution. Soap, soda, lye, all have been tried without much success. The fibers, however, once obtained, can be readily freed from the gummy matters which inclose them, either by beating after drying or by chemical agents. This latter is operated by means of caustic lyes without much difficulty. When freed from gum the fibers are bleached and combed. They are then ready for the thread. This, when completed, can be adapted to all or nearly all the departments of textile industry, and promises to be more extensively used in the immediate future.

MONT DORE, WEST KIRBY, CHESHIRE.

Our illustration is the design for the proposed building to be erected at West Kirby, on the estuary of the Dee, overlooking the Welsh Hills, the site being admirably suited for the purpose. The building, which is E-shaped on plan, is intended to accommodate some 150 visitors and patients for the treatment known as the Mont Dore cure; the center being apportioned to the baths required for this special system of treatment. Care has been taken in designing the building to arrange for every individual requirement, and from the entrance hall beneath the tower hydraulic lifts will be provided to carry visitors and patients to the various apartments. A ballroom in the center of the block, comprising two floors in height, will be provided, together with dining, drawing, library, smoking, and billiard rooms. The exterior, as shown by the view, is designed in half timber, red brick, and roughcast, in the characteristic style of the county. The estimated cost is about £50,000, exclusive of esplanade and laying out of grounds. The building is the joint design of Mr. A. Bedborough, A.I.C.E., and Messrs. Wheeler and Hollands, F.R.I.B.A.—*Building News.*

The Building News, Mar. 14. 1884.



West-Kirby ● Mont-Dore ● Cheshire

THE CRYSTALLIZATION OF PHOSPHORIC ACID.*

By P. L. Huskisson.

The crystalline form of phosphoric acid was first noticed by Süersen, Steinacher, and Stromeyer, who obtained it in well defined crystals by evaporating a solution of the acid until it had the exact composition of H_3PO_4, a result which was confirmed by Krämer in 1869.

Péligot, in a paper read before the Académie des Sciences in the year 1840, stated that fused metaphosphoric acid, left in a bottle several years, absorbed water and formed at the top transparent crystals of orthophosphoric acid, in the middle a mother liquid of specific gravity 1·7, and at the bottom opaque, indistinct crystals of pyrophosphoric acid, resembling loaf sugar.

Quite recently, however, Mr. H. P. Cooper, in a paper read before the Pharmaceutical Conference 1881, stated that he had been unable to start crystallization in a solution of phosphoric acid, even when concentrated to a specific gravity of 1·850, without the introduction of some foreign substance, and used crystals of sulphate of sodium for that purpose.

Having observed certain facts in connection with the crystallization of phosphoric acid, which seemed to point to a different conclusion, the following experiments were made upon the subject.

It ought perhaps here to be mentioned, that during the winter of 1880–81 several bottles of 1.750 acid phosphoric in my father's laboratory, suddenly and without any apparent cause, crystallized, and it was with these crystals that some of the following experiments were made.

Starting with one of these crystals, if it was dropped into an acid of specific gravity 1·750, it was observed that the moment it touched the liquid it began to grow and rapidly filled the flask, evolving at the same time a large amount of heat. The crystals thus formed were in prismatic plates, hard and transparent, and at ordinary temperatures easily kept in that state, if inclosed in stoppered bottles.

Experiments were then made with phosphoric acid of different strengths, and an acid of specific gravity 1·750 was the highest, and specific gravity 1·660 the lowest, that could be crystallized at the ordinary temperature. The weaker acids ought, at the time of crystallization, to be surrounded by water, as the heat evolved by the first few crystals forming is sufficient to redissolve them and prevent the formation of others. The shape of the crystals from the weak solutions is especially well defined; they are transparent and in prismatic needles.

Endeavors were then made to start crystallization in an acid of specific gravity 1·750, with a number of other crystals, both of the same and other groups, but without success, the following crystals being used:

Acetic acid glacial, alum, ammonium oxalate, ammonium nitrate, ammonium phosphate, arsenic acid, barium nitrate, borax, boric acid, cadmium nitrate, copper sulphate, iron sulphate, lead nitrate, manganese sulphate, mercurous nitrate, oxalic acid, phenol, potassium bromide, potassium chlorate, potassium iodide, potassium nitrate, potassium sulphate, red potassium chromate, silver nitrate, sodium arseniate, sodium phosphate, sodium sulphate, tartaric acid, zinc sulphate.

It was then tried to crystallize some acid by concentration, evaporating carefully so as to prevent the formation of meta or pyrophosphoric acids; but although acid of the specific gravity 1·860 was obtained, no crystals appeared. Finally some acid of specific gravity 1·750 was evaporated for one hour, keeping it at 160° C. (320° F.), and the evaporation finished *in vacuo*, when some tabular transparent crystals were obtained, which as soon as they came in contact with the air changed their form and became opaque, giving out at the same time a large amount of heat. The different behavior of this acid, in crystallizing *in vacuo* while stronger acids in the air refuse to do so, is due to the fact that the acid absorbs water very readily.

When these crystals are dropped into acid phosphoric of specific gravity 1·750 no action takes place, nor can crystallization be in any way induced at that strength; but at a gravity of 1·800 it will take place readily after a short time.

It is interesting to notice that if a crystal of the former acid be placed in some phosphoric acid of specific gravity 1·800, nothing results; but if a few drops of water be added, so as to reduce the strength, crystallization immediately begins.

As the attempt to crystallize phosphoric acid of specific gravity 1·750 with sulphate of sodium failed, two samples of specific gravities 1·800 and 1·850 were prepared, and into each a crystal of sulphate of sodium was placed, well stirred, and left for thirty-eight hours. At the end of this time both samples were carefully examined, but in neither had any crystals made their appearance.

The results of these experiments indicate—(1) That a solution of phosphoric acid cannot be crystallized by any means, when the specific gravity is lower than 1·660, at ordinary atmospheric temperatures. (2) Solution of phosphoric acid of specific gravities 1·660 and upward will not under ordinary conditions crystallize spontaneously or upon agitation. Neither can it be crystallized by the introduction of sodium sulphate or any other foreign crystal. When a crystal of orthophosphoric acid is introduced, crystallization at once commences. (3) Phosphoric acid having a specific gravity of 1·800 can be crystallized spontaneously by exposing over sulphuric acid *in vacuo*. The crystals then produced are unable to start crystallization in phosphoric acid of lower

* Read at a meeting of the School of Pharmacy Students' Association, February 7.

specific gravity than that from which they have been produced (1·800), and on the other hand the crystals obtained from weaker solutions are unable to induce crystallization in the stronger acid of specific gravity 1·800.

ATOMATION OF OXYGEN AT ELEVATED TEMPERATURES, AND THE PRODUCTION OF HYDROGEN PEROXIDE AND AMMONIUM NITRITE, AND THE NON-ISOLATION OF OZONE IN THE BURNING OF PURIFIED HYDROGEN AND HYDROCARBONS IN PURIFIED AIR.

By Albert R. Leeds.

It has heretofore been established, by the fact of the conversion of carbon monoxide into dioxide during the slow oxidation of phosphorus, that the formation of ozone, hydrogen peroxide, and ammonium nitrite, in the course of this eremacausis, is preceded by the resolution of the oxygen molecule into its constituent atoms. The converse of this proposition, viz., that when oxidation occurs with the contemporaneous formation of the three products enumerated, this oxidation has been preceded by the production of atomic oxygen, has not as yet been satisfactorily established, and awaits experimental proof.

The object of this second paper is to present the conflicting testimony as to whether these three bodies are formed during the rapid combustion of hydrogenous substances, and the results of a new experimental inquiry.

According to Schönbein, the formation of ozone occurred in all cases of slow oxidation in presence of atmospheric air. Moreover, that when readily oxidizable metals, like zinc and iron, were agitated in contact with air and water, hydrogen peroxide was formed. Also, that ozone, in presence of air and moisture, would generate ammonium nitrite.

This last statement, after long controversy, has been satisfactorily disproved by Carius.* Satisfactorily, because Berthelot,† working independently and at a later period, has entirely confirmed the results obtained by Carius. It has thus been established beyond reasonable doubt, that ozone in presence of moist atmospheric air or moist nitrogen will generate neither ammonium nitrite nor nitrate.

At the same time it is no less certain that in the slow oxidation of phosphorus, the contemporaneous formation of ammonium nitrite, ozone, and hydrogen peroxide takes place. And while the observations of Schönbein and others, as to the occurrence of the same phenomena in the course of the slow oxidation of metals, have not been reinvestigated with the same minuteness as the oxidation of phosphorus, yet it is eminently probable that the correctness of his labors in these particulars will be eventually vindicated. In this connection the recent controversy and final establishment of the fact of the production of both hydrogen peroxide and ammonium nitrite, when the hydrogen in palladium hydrogen undergoes slow oxidation in presence of air and moisture, is very instructive.

After the researches of Marignac, Andrews, Soret, Brodie, and others had elucidated the true nature of ozone, a very different interpretation was put upon many of the experimental results obtained by Schönbein from that put forth by their original observer. Instead of regarding, as Schönbein did, ozone or the fictitious antozone as the starting point in certain sequences of phenomena, the hypothesis was advanced in various quarters, that the real starting point was an initial change in the oxygen molecule, necessarily antecedent to all the observed phenomena.

In any new investigation of this topic it is but just to previous observers to rehearse the history of their labors, and in so doing the difficulties encountered are of two kinds:

1. To ascertain in regard to particular experiments whether the reactions noted were in reality due to their ascribed causes.

2. To restate the theoretical explanation of these phenomena in the light of the present universally received doctrines concerning the true nature of ozone.

One of the earliest observations relating to the subject matter of the present paper was that contained in a brief communication made to the Lyceum of Natural History of New York in 1869, by Loew.‡ His experiment was of a very simple nature. He blew a strong current of air through a fine tube into the flame of a Bunsen burner, and collected the air in a beaker glass or balloon. He stated that in the course of a few seconds sufficient ozone could be collected in this manner to be identified by its intense odor and the common tests.

Subsequently, a large apparatus containing many jets and burners was patented by Loew, and applied to the mellowing of whiskies by means of the "ozone" thus formed.‖

The production of ozone in the manner described was immediately denied by Boeke, who substituted a blast of oxygen for the air expired from the lungs, and obtained from the gaseous products the reactions and odor of a compound of nitrogen and oxygen.§

Böttger likewise denied the accuracy of Loew's results, but upon altogether different grounds.¶ He detected no ozone in air blown through the flame of a Bunsen burner, but ammonium carbonate (which he regarded as a regular constituent of air expired from the lungs) and hydrogen peroxide. In reply to these criticisms, Loew repeated his experiments, using, instead of expired air, a bellows and a large Bunsen burner, and stated that in this manner he filled in a short time a large room with the peculiar odor due to ozone, while delicate tests failed to detect any peroxide of hydrogen or ammonium carbonate.

Similar experiments were performed by Than.** This observer aspirated the products of combustion from the lower edge of the flame of a Bunsen burner through an acidulated solution of potassium iodide and starch. A blue coloration was speedily produced, the air in the wash bottle smelling distinctly of ozone. When pure water was used as an absorbing solution, and subsequently tested with potassium iodide and starch, no blue color was developed. From this negative result the absence of ammonium nitrite was inferred, and from the previous affirmative result the presence of ozone. But the formation of ammonium nitrite as a product of combustion of hydrogen has since that time been established beyond doubt, while the reactions for ozone obtained by Than permit of other explanations.

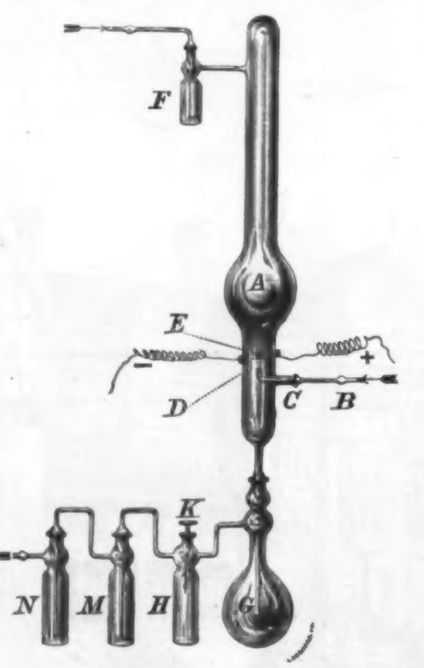
Similar objections apply to the experiments performed by Struve (1871),* who endeavored to prove that ozone, hydrogen peroxide, and ammonium nitrite are all present in the products of combustion of hydrogen. The gas was burned beneath a long drawn out funnel, and tests were made for ozone at the upper end of the funnel, while the water condensed on its sides was collected and examined for hydrogen peroxide and ammonium nitrite.

In Poggendorff's Annalen for 1872 (p. 480), a summary is given of the results obtained by Pincus upon the formation of ozone, when thoroughly purified hydrogen gas was burned in atmospheric air. The gas was burned with the smallest possible lens shaped flame from a metal jet. According to Pincus, when a cold and clean beaker glass was held over the flame the contents of the beaker possessed as powerful an odor of ozone as the interior of a charged Leyden jar. When pure oxygen was substituted for atmospheric air in a properly constructed apparatus, the same phenomena occurred, showing that the nitrogen of the air was not essential to its development.

The merit of having established, by rigorous experimental proof, the formation of ammonium nitrite by the burning of hydrogen thoroughly purified in thoroughly purified air, is due to Zoeller and Grete.† In their apparatus the air and hydrogen were purified by passage through potassium permanganate, potash, sulphuric acid, and Nessler's reagent, and the absence of both nitrous acid and ammonia in the gases prior to combustion most carefully demonstrated. The hydrogen was burned in a jet 3 to 4 mm. high, issuing from a platinum blowpipe tip. The ammonia formed by combustion was converted into ammonia platinum chloride, the nitrous acid was identified by diamido benzole and other tests. Nitric acid was sought for, but no reaction for it was obtained. The authors make no mention of either ozone or hydrogen peroxide.

In entering upon the present investigation of this difficult topic, it was with the hope of constructing an apparatus in which, by the use of completely purified gases and the elimination of all surfaces of contact with organic bodies, it would be possible to decide whether at one and the same time ozone, hydrogen peroxide, and ammonium nitrite (and possibly nitrate) were formed in process of combustion of hydrogenous substances.

The apparatus employed is figured in the accompanying



cut. The combustion chamber, A, consists of a tall glass cylinder, 80 cm. in height, and 6 cm. in diameter, with a globular enlargement. At the bottom it connects, by a tube passing through a stopper of ground glass, with the receiving vessel, G. This vessel communicates with the bottle, H, whose stopper, K, is provided with a platinum hook fused in to its lowest part. H communicates with the wash flasks, M and N, by tubes passing through their mouths and ground into them air tight. The entrance tube, B, passes through the ground glass joint, C, and is fused to the platinum jet, D. Platinum wires connected with a coil are twisted into a very small spiral, E, which is interrupted so as to allow of the passage of a spark immediately above the jet. At the upper portion of the chamber, A, there is a lateral tube connected with a wash flask, F, which is provided with an entrance tube passing through its stopper of ground glass.

In the performance of the experiments, the air, after passage through a long tube filled with ignited asbestos, was passed through water, potassium permanganate, potash, sulphuric acid, and Nessler's reagent, entering at the upper end of the combustion chamber by the wash flask, F. It encountered the hydrogen similarly purified at E, and combustion was brought about by passage of the spark at this point. The platinum spiral was made very small, so as to be contained within the outer surface of the flame. This was done to obviate the possible error due to the contact of platinum at high temperatures with the mixed gases. At the same time some device of this character was necessary, since the perfectly purified hydrogen gave an invisible flame, and it could not be certainly known, except by the incandescence of the platinum, whether the flame had gone out or not. Without the platinum, extinction of the flame was very apt to occur, but with the platinum this never happened. The products of combustion flowed down into G, in which vessel and in H and M they were entirely condensed, these vessels being kept cold by ice. N contained a solution of potassium iodide, free from iodate and other impurities.

On opening the apparatus, in none of the trials was the odor of ozone noted. The potassium iodide alone, or after addition of starch water, was never affected when pure hydrogen was burned. When illuminating gas was used, the potassium iodide solution gave no indications of decomposition by ozone on application of tests. If starch was added to it, a faint reddish precipitate was formed. On filtering off this precipitate, washing thoroughly with water, and allowing it to remain in contact with air, it became violet in color. Unfortunately, the amount was so small that the nature of this yellow precipitate could not be determined with certainty. Aldehyde passed into a solution of potassium iodide starch yielded a yellow precipitate, turning first violet and then blue on exposure to air. But these experiments are apart from the main purpose of the investigation, and the deportment of potassium iodide alone or with starch sufficiently established the fact that no ozone passed through the wash bottle, N.

The condensed water gave an intense reaction with the Griess tests. When pure hydrogen was used the percentage of nitrous acid was 0·005 part in 100,000, that of ammonia 0·002 part per 100,000. These quantities are in the proportion corresponding to ammonium nitrite. The amount of hydrogen peroxide much exceeded that of ammonium nitrite, being 17 parts per 100,000. The various tests for hydrogen peroxide, in which potassium iodide enters as one of the constituents, were not relied upon as conclusive, since the results obtained might have been due to other substances possibly present. But the condensed water gave in addition an intense blue color with fresh cold extract of malt and fresh guaiacum tincture. Moreover, it developed with solution of chromic acid a strong blue color, the last being regarded as the most satisfactory of the tests applied to prove qualitatively the presence of hydrogen peroxide. No nitric acid was detected.

The amounts of nitrous acid, ammonia, and hydrogen peroxide obtained when purified illuminating gas was burned were not determined, but the qualitative tests applied to establish their presence were the same as those used in the case of pure hydrogen, and were equally satisfactory.

It should be observed that an apparatus of the character described is not well adapted to settle the question of the possible formation of ozone. The products of the combustion could not be rapidly withdrawn from the influence of the elevated temperatures in the immediate vicinity of the flame, and any ozone formed could readily have undergone decomposition. The experiment is a failure, in so far as its bearing upon the validity of the observations made by preceding observers is concerned. In all of their experiments the immediate withdrawal of the products of combustion is an ess ntial feature. In repeating their experiments, if other evidence than that afforded by the powerful odor of ozone is sought for, it would be necessary to obtain the absorption spectrum of ozone and the blackening of silver. Under the conditions of the experiment, other qualitative tests for the presence of ozone would be open to question. The amount of ozone necessary to yield these decisive proofs, however, is much greater than that which could possibly be obtained in any trial where all the essential precautions are observed. For these reasons further experiments are abandoned.

The final conclusion reached is the *certain formation* of hydrogen peroxide and ammonium nitrite, and, in view of the fact that the statements of others concerning the presence of ozone have not been disproved, the *possible formation* of ozone.

* Ann. der Chem., clxxiv., 31.
† Compt. Rend., lxxxiv., 61.
‡ Chem. News, xxii., 13.
‖ Wagner's Jahresb., 1874, p. 404; Dingl. Polyt. Jour., ccxiii., 306.
§ Chem. News, xxii., 24.
¶ Chem. Centr., 1870, p. 161.
** J. Pr. Chem. [2], i., 415.

* Zeitsch. Anal. Chem., x., 299.
† Ber. Bericht., x., 2144.

INCUBATORS FOR INFANTS.

On the Boulevard Port-Royal, Paris, in the neighborhood of the Observatory, surrounded by a tall, gray stone wall that bears the marks of age, stands the old convent founded by Angélique Arnaud in 1625, a picturesque agglomeration of buildings with spacious courtyards and cloisters and gardens. Over the doorway hangs a dirty tricolor flag, while the inscriptions "Liberte, Egalite, Fraternite" and "Maison d'Accouchement" indicate that the convent, so memorable in the intellectual history of France, has had its destination changed. The convent of Port-Royal is now the great lying-in hospital of Paris, commonly known by the name of "La Maternite," the refuge of unfortunate mothers. The cells where the nuns used to live and meditate are now occupied by austere hospital beds; the old gardens have become the recreation ground of the student midwives, whose youthful looks and neat uniform throw a note of gayety over the vast and naked-looking wards; and the pious superior has been replaced by a man of science, the eminent obstetrician, Professor Tarnier. In visiting La Maternite, with the literary souvenirs of Port-Royal fresh in one's mind, one is struck by all these contrasts; but when one is ascending a fine old Louis XIV. staircase, one is hardly prepared to be invited to inspect, in the first ward on the right, M. Tarnier's new "Couveuse pour Enfants." An incubator for children! What does that mean? Do they hatch children, nowadays, like eggs?

In the accompanying illustration the reader will find a representation of these incubators, which have been employed with great success at La Maternite since 1881, and which are now being introduced into the other Paris hospitals. Science has long been preoccupied with the question of the treatment of feeble, and especially of prematurely born, children. M. Tarnier's incubator is the latest contribution to the solution of the problem. One of these incubators employed at La Maternite, the one on the old model, is composed of a wooden box, the sides of which are about 4 or 4½ inches thick, hollow, and filled with sawdust for the sake of insulation. This box, resting on a stand 3 feet high, is 27 inches broad and 31 inches deep; it is divided into two compartments by a central partition. In the upper compartment is placed the infant, and in the lower one a metal reservoir, containing about 15 gallons of hot water. To this reservoir is fitted a thermo siphon, by means of which the water may be heated with gas, spirits of wine, or a petroleum lamp; and between the reservoir and the inclosing box a space is left for the circulation of the air, which enters at the bottom of the box, rises at it becomes heated, and escapes through orifices in the lid of the box, which is fitted with a pane of glass. The upper compartment has, besides the movable glass lid, a lateral door, through which to slide the cradle in and out; and it is separated from the lower compartment by a board pierced with holes, through which the warm air penetrates. The temperature of the upper compartment thus heated is maintained at about 89½ deg. Fahrenheit. At the Lariboisiere hospital 98 deg. Fahrenheit are taken as the standard; but this question of the temperature to be preferred has not yet been definitely settled. As regards the means of heating the incubator, gas is employed at the Hopital de la Charite, and an electrical alarm bell attached to a Regnard regulator rings when the temperature rises beyond a certain point.

The second model of incubator employed by M. Tarnier, and also represented in our illustration, is much simpler and cheaper, and less bulky. It consists simply of a wooden box 25 in. long, 14 in. broad, and 20 in. high, outside measurement. The wood is one inch thick, and may be coated with

felt or padded inside. This box is divided into two parts by a board, some 4 in. shorter than the box, and placed at a height of 6 in. from the bottom. In the lower compartment are two lateral openings fitted with sliding doors: one, which can never be completely closed, gives passage to the air; the other is for the introduction of the stone bottles containing hot water, called in Paris *moines*, which are employed to heat the apparatus. The upper compartment, covered by a closely fitted glass lid, receives the infant, and at one end is an orifice, furnished with a chimney and a revolving ventilator, through which the air escapes. In the opening that separates the two compartments is hung a thermometer with a wet sponge to moisten the air. The air enters at the bottom, passes over the bottles of hot water, rises into the upper compartment, passes over the whole length of the infant, and so out at the orifice at the end. The hot-water bottles hold each somewhat above a pint, and five of them may be placed in the incubator, but it is generally found that four suffice to maintain a temperature of 88 deg. to 89½ deg. Fahrenheit, the temperature of the room being 62 deg. to 66 deg. The heating is continued by changing one of the bottles about every two hours, and with this system there is no danger of overheating. This incubator is so simple that any village carpenter can make it, and cheap enough to be within the means of all but the most destitute. The infants placed in incubators at La Maternite, if they are strong enough, are fed by nurses, or else with asses' milk, administered with a spoon, the feeding bottle being prohibited in this establishment. The operations of feeding, washing, and dressing the infants placed in incubators are performed in the room at the ordinary temperature of 62 deg. to 66 deg., for the infants do not appear to be any more sensitive than other infants, and exposure to the air for a short period does them no harm. The infant in the incubator is dressed in ordinary swaddling clothes. The results obtained at La Maternite by the employment of incubators have been very satisfactory.—*Illustrated London News.*

INCUBATORS FOR INFANTS.

DR. TARNIER, an able surgeon at the Maternite, Paris, probably taking his hint from the incubators that are used for hatching chickens, has devised a similar apparatus for protecting prematurely born infants from the influence of the air, and permitting them to develop without accident.

This device consists of a wooden box or case one meter in height by seventy centimeters in width, and having double sides. The space between these latter (10 cm. in width) is filled in with sawdust. The box is divided into two compartments that communicate at the sides. In the lower part there is a metallic water reservoir, which is held by hooks, so as not to touch the sides, and which forms a conduit all around the box for the circulation of the hot water for heating the air. To this reservoir there is adapted a thermo siphon which is external to the apparatus. The upper compartment, which receives the infant's bed, communicates with the lower one through lateral apertures, and opens externally through a sliding plate of glass which permits of complete occlusion.

The operation of the apparatus is very simple. It is only necessary to light a small alcohol or kerosene lamp under the thermosiphon, in order to quickly heat the water in the reservoir to the required degree. During the cold season it is necessary, as a general thing, to light the thermo siphon lamp three times a day, and allow it to burn for about two hours at a time. As soon as the temperature in the upper compartment has reached to within about two degrees of that which it is desired to obtain, the lamp should be extinguished. For a few minutes, in fact, after the extinction of the lamp the temperature continues to rise; and experience has shown that this increase is about two degrees. During warm weather it is ordinarily sufficient to light the lamp twice a day. Great care is necessary in using the apparatus. If the temperature descends, all the benefits of the method are lost, and if it rises the child runs the risk of being burned. In order to prevent all possible accidents, the apparatus is provided with a small electric armature, which acts as soon as the desired degree of temperature is exceeded, and causes an alarm bell to ring. But it is simpler to do as Dr. Tarnier does, and only partially rely upon such precautionary apparatus. Two or three times a day, or oftener if need be, a certain quantity of the water is removed from the apparatus and replaced by an equivalent quantity of boiling water. By these means there may be obtained during the first two hours a temperature of from 29 to 30 degrees, and this will not descend to 26 or 26 until after about twelve hours. According to the observations of accoucheurs, this is just the proper degree, although a few demand two or three degrees more.

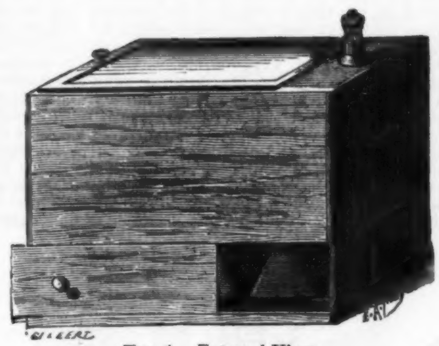


FIG. 1.—External View.

FIG. 2.—Section.

INCUBATOR FOR INFANTS.

The air that enters at the base circulates around the reservoir, reaches the upper compartment at a sufficient degree of heat, and from thence escapes through a tube in the cover. The infant, immediately after birth, and after the first cares have been given it, is put into the apparatus clothed like other nurslings, and makes its exit therefrom only when it is sufficiently hardy and strong to live like other children in the open air. Every two or three hours it is taken out for a few minutes to be nursed at the breast, or, if sick, to be fed upon asses' milk. The length of time during which it remains in the apparatus varies, it will be understood, with each case. One infant may remain but a few days therein, while another may have to remain a fortnight or more. An example is cited of a six month's child, weighing 1,720 grammes, that remained in the box forty-six days, while another one, of six and a half months, obtained a sufficient amount of strength in five days only.

As the apparatus employed in hospitals, and described above, is quite high priced, Dr. Achard, of the Maternite, has devised something simpler and within the reach of private practitioners. His apparatus (shown in Figs. 1 and 2, from *La Nature*) is as simple wooden box 50 centimeters in height, 65 in length, and 36 in width. The interior is divided into two parts by an incomplete partition. In the upper part is placed the infant, and below there are introduced earthen vessels filled with boiling water, which are renewed one after another, according to the needs of the case, about every two hours. Air vents are provided as in the large model above described, and a glass cover permits of the child being removed for nursing and of its being watched. When the water vessels are renewed in this apparatus, as directed by its designer, there is no danger of too great a degree of heat being attained.

CROTON OIL.

THE investigations of Mr. Harold Senier, Fellow of the Chemical Society, into the active principles of croton oil are not without considerable interest to the physician. Mr. Senier read to the Pharmaceutical Society on Dec. 5th a paper in two parts—one on the vesicating principle in croton oil, the other on the purgative principle in croton oil. In 1878, in a former paper, he gave the results of an investigation into the action of alcohol on croton oil, and showed that under certain conditions it separated the oil into two parts—the one part vesicating, the other non-vesicating. The non-vesicating oil Mr. Senier has since shown to be purgative. The conditions referred to are that the alcohol shall be of specific gravity 0·794 to 0·800, and in the proportion of seven volumes to six, or any larger proportion. If the alcohol and oil are mixed in equal volumes perfect solution takes place, and this holds of a mixture with any less quantity of alcohol. But when the volume of alcohol exceeds that of croton oil, a part of the croton oil separates. This part varies in quantity in different samples of the oil. The part so separated is afterward insoluble in any proportion of alcohol. But that portion of oil dissolved by alcohol is, when separated, soluble in all proportions. Mr. Senier has found that the part soluble in alcohol as above used was, or contained, the vesicating principle, and that the vesicating activity does not exist in the free acids nor in any basic constituent, but resides in the combined non-volatile fatty acids. Mr. Senier further finds that the purgative constituent does not reside in the alcohol-soluble vesicating oil, but entirely in the alcohol non-soluble, non-vesicating oil. In support of this conclusion he refers in his paper to experiments on himself and others. He further says that the conclusion is borne out by a study of the therapeutic action of this non-vesicating oil by Dr. J. W Meek. The general result of these experiments is that in this

INCUBATORS FOR INFANTS AT THE MATERNITY HOSPITAL, PORT-ROYAL, PARIS.

non-vesicating oil, in doses from one-tenth to one-half a minim, administered in the form of pills, with magnesium carbonate and extract of henbane for excipients, we have a safe and mild or powerful purgative, according to the dose, unaccompanied by any unpleasant symptoms. No purgative action was obtained by administering the vesicating oil in a similar way, but a considerable amount of irritation in the alimentary canal, accompanied with nausea. The medical importance of Mr. Senier's investigations is obvious, and justifies the hope that we shall be able to extract a more practicable and effective purgative from croton oil, minus the violent and irritating powers which the physician is apt to associate with the drug in its entire form.—*Lancet.*

RECENT PROGRESS IN DYNAMO ELECTRIC MACHINES.*

By Professor SILVANUS P. THOMPSON, B.A., D.Sc., M.S.T.E. University College, Bristol.

FIFTEEN months ago, I had the honor of delivering in this place a course of three Cantor lectures on "Dynamo Electric Machinery." In the first of those lectures, the endeavor was made to trace out a physical theory of the action of dynamos, and to follow the theory into its bearings upon the construction of such machines. In the second lecture, a large number of actual machines were considered and compared with one another and with the theory; and in the third lecture, the dynamo was considered in its functions as a mechanical motor.

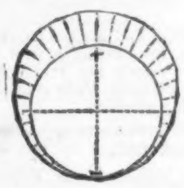


FIG. 1.—Diagram of Potential round the Collector of Gramme Dynamo.

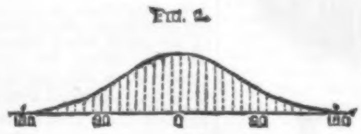


FIG. 2.—Horizontal Diagram of Potentials at Collector of Gramme Dynamo.

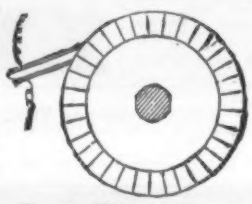


FIG. 3.—Method of Experimenting at Collector of Dynamo.

As the present paper may be considered supplementary to the Cantor lectures, it will be convenient to treat of the features of progress which come to-night under review in a similar order of topics. I, therefore, take up first the theory of the dynamo.

There are, in fact, three distinct theories of the dynamo: (1) a physical theory, dealing with the lines of magnetic force

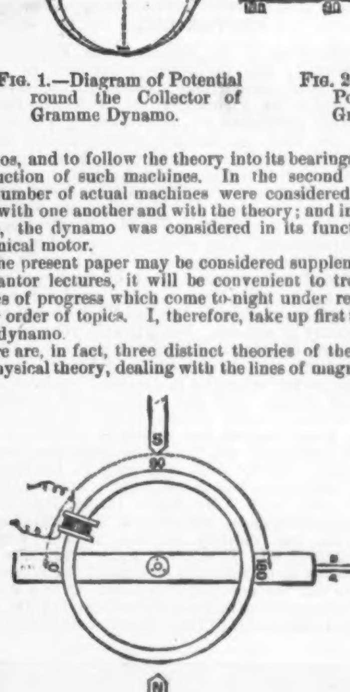


FIG. 4.—ISENBECK'S APPARATUS.

and lines of current in which these quantities are made, without further inquiry into their why or how, the basis of the arguments; (2) an algebraical theory, founded upon the mathematical laws of electric induction and of theoretical mechanics; and (3) a graphical theory, based upon the possibility of representing the action of a dynamo by a so-called "characteristic" curve, in the manner originally devised by Dr. Hopkinson, and subsequently developed by Frölich, Deprez, and others. The last of these three methods, though it has not received any great or striking development during the past year, has proved itself to be the most invaluable aid in the practical construction of dynamo machines. One has only to refer to the use made of charac-

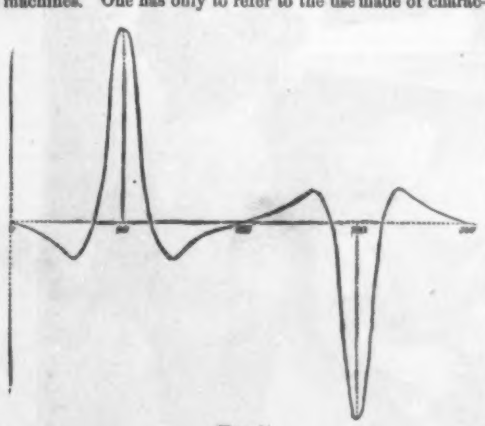


FIG. 5.

teristics by Mr. Kapp in his articles on the winding of "compound" dynamos, and, still more recently, by Dr. Hopkinson, in solving certain problems in the electric transmission of energy, to see how invaluable the method is.

In the algebraic theory much progress has been made during the past year; and there certainly was room for it. Monsieur Joubert has published, in the *Journal de Physique* for July, 1883, a long mathematical article, the object of which is to deduce the equations of the dynamo, taking into account not only the action of self-induction in the circuit, but also some of the terms of the second order usually neglected in first approximations. It is a question whether he has not still omitted some terms of quite as great an importance as those retained in the complicated formula deduced by him. But the matter can hardly be discussed in the present paper. Still more recently, Professor Clausius has published in Wiedemann's *Annalen*, for November last, a paper expounding a mathematical theory of dynamo electric machines far more comprehensive, and, I venture to say, far more true, than any other yet put forward. Without shirking any of the mathematical difficulties presented by the complications of mutual induction between, and self-induction in, the various organs of the machine, and by the admitted incompleteness of all our formulæ for connecting the magnetism of an electro-magnet with the strength of its exciting current, Prof. Clausius has succeeded in putting the equations into a shape, not only far more satisfactory from the point of view of completeness, but in framing those equations in a manner that must commend itself to every engineer. The relative simplicity attained by Clausius is, in fact, due to his lavish introduction of a set of arbitrary constants, each one of which having values that must be determined by experiment, for each machine or type of machines. The number of new symbols thus introduced is considerable; and it would be very desirable to find names for the separate constants to be determined. An excellent translation has appeared in the *Philosophical Magazine* of this year, and another is in process of publication in *The Electrician*, in which journal the series of articles on the theory of dynamo electric machines from the pen of Professor O. J. Lodge is still continued. It cannot be said even yet that the mathematical theory of the dynamo is near completion. A further paper by Professor Clausius is promised; and it remains to be seen whether this article will deal with some of those points in which the graphic method has been so useful in practice, for example, in determining the proper quantities of wire for the coils in "self-regulating" or "compound" machines, and in finding the best shape to give to magnets and pole-pieces.

Turning to the physical theory of the dynamo, there is much to record. Our knowledge of the inductive actions which go on between the field magnets and armatures of dynamos has received considerable additions during the past year from the researches of Isenbeck, Cunnynghame,

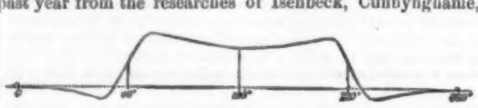


FIG. 6.

Pfaundler, and others. There is a good deal to be said on this head, and I have several new results to announce as the result of my own observations. Let me take as my starting point a matter mentioned in my Cantor lectures, namely, the distribution of potential round the collector or commutator of a dynamo. Mr. W. M. Mordey, who first drew my attention to the fact that this distribution was irregular in badly designed machines, had devised the following method of observing it. One terminal of a voltmeter was connected to one of the brushes of the dynamo, and the other terminal was joined by a wire to a small metallic brush or spring, which could be pressed against the rotating collector at any desired part of its circumference. I then made the suggestion that these indications might with advantage be plotted out round a circle corresponding to the circumference of the collector. Figs. 1 and 2, which are reproduced from my Cantor lectures, serve to show how the potential in a good Gramme machine rises gradually from its lowest to its highest value. The same values as are plotted round the circle in Fig. 1 are plotted out as vertical ordinates upon the level line in Fig. 2. I made the remark at the time that

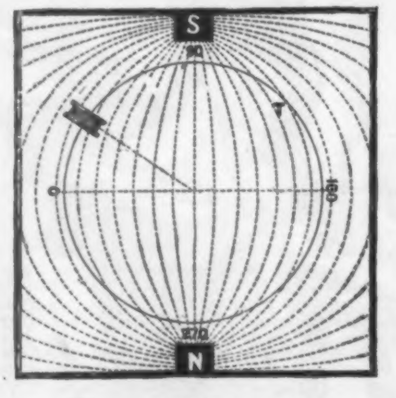


FIG. 7.

if the magnetic field in which the armature rotated were uniform, this curve would be a true "sinusoid," or curve of sines; and that the steepness of the slope of the curve at different points would enable us to judge of the relative idleness or activity of coils in different parts of the field. About the same time, I developed this method of observation a little further, and used two small metal brushes, at a distance apart equal to the width between the middle of two consecutive bars of the collector of my little Siemens dynamo, for the same purpose.* As the collector rotated, these two little brushes (see Fig. 3) gave on the voltmeter an indication which measured exactly the activity of the induction, in that section of the armature which was passing through the particular position in the field corresponding to the position of the contacts. I found, in the case of my Siemens dynamo, that the result was fairly satisfactory, for the difference of potential indicated was almost *nil* at the sections close to the proper brushes of the machine, and was a maximum about half way between. In fact, the difference of potentials was rising most markedly at 90° from the usual brushes, or precisely in the region where (as seen in Fig. 2) the slope of the curve of total potential was greatest. One immediate result of Mr. Mordey's observations on the distribution of potential, and of my method of mapping it, may be recorded. I pointed out to Mr. Mordey that in a dynamo

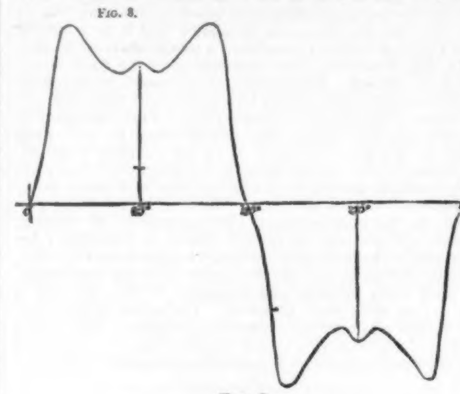


FIG. 8.

where the distribution was faulty, and where the curves of total potential showed irregularities, the fault was due to irregularities in the induction at different parts of the field; and that the remedy must be sought in changing the distribution of the lines of force in the field by altering the shape of the pole-pieces. I am able now, after the lapse of fifteen months, to congratulate Mr. Mordey on the entire and complete success with which he has followed out these suggestions. He has entirely cured the Schuckert machine of its vice of sparking. The typical bad diagram given in my Cantor lectures was taken from a Schuckert machine before it received from his hands the modifications which are so signally successful to-day.

Since the experiments above detailed, I have experimented on my Siemens dynamo in another way. The machine was dismounted, and its field magnets separately excited.

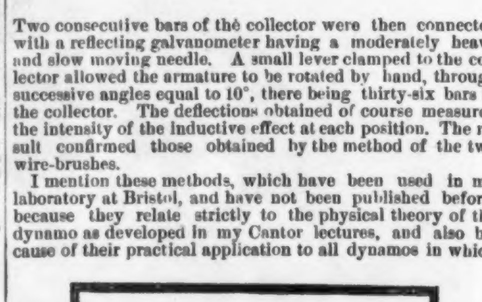


FIG. 9.

Two consecutive bars of the collector were then connected with a reflecting galvanometer having a moderately heavy and slow moving needle. A small lever clamped to the collector allowed the armature to be rotated by hand, through successive angles equal to 10°, there being thirty-six bars to the collector. The deflections obtained of course measured the intensity of the inductive effect at each position. The result confirmed those obtained by the method of the two wire-brushes.

I mention these methods, which have been used in my laboratory at Bristol, and have not been published before, because they relate strictly to the physical theory of the dynamo as developed in my Cantor lectures, and also because of their practical application to all dynamos in which

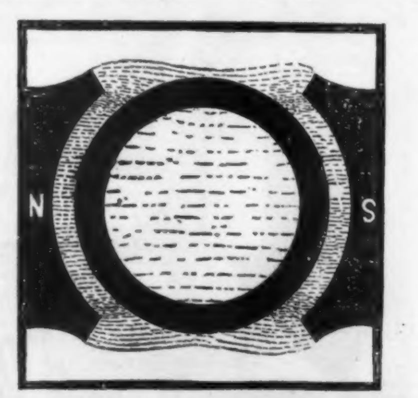


FIG. 10.—IRON RING IN THE MAGNETIC FIELD.

any such defect appears. They are also very closely related to the researches of Dr. Isenbeck, which next claim attention.

Dr. Isenbeck described, in the *Electrotechnische Zeitschrift* for last August, a beautiful little apparatus for investigating the induction in the coils of a Gramme ring, and for investigating the influence exerted by pole-pieces of different form upon these actions.

Isenbeck's apparatus (Fig. 4) consists of a circular frame of wood placed between the poles of two small bar-magnets of steel, each 25 centimeters long, lying 25 centimeters apart. On the frame, which is pivoted at the center, is carried a ring of wood or iron, upon which is placed at one

* A recent lecture before the Society of Arts, London.

* Dr. Isenbeck has also independently used a similar arrangement to investigate the induction going on in a Gramme dynamo.

point a small coil of fine wire. This corresponds to a single section of the coils of a Pacinotti or of a Gramme ring, of which the ring of wood or iron constitutes the core. The coil can be adjusted to any desired position on the ring, and the ends communicate with a galvanometer. On vibrating it isochronously with the swing of the needle of the galvanometer, the latter is set in motion by the induced currents, and the deflection which results shows the relative amount of induction going on in the particular part of the field where the coil is situated. The vibrations of the frame are limited by stops to an angle of 7° 5'. Pole-pieces of soft iron, bent into arcs of about 160° so as to embrace the ring on both sides, but not quite meeting, were constructed to fit upon the poles of the magnets. In some of the experiments a disk of iron was placed internally within the ring; and in some other experiments a magnet was placed inside the ring, with its poles set, so as either to re-enforce, or to oppose, the action of the two external poles. In Dr. Isenbeck's hands this apparatus yielded some remarkable results. Using a wooden ring, and poles destitute of polar expansions, he observed a very remarkable inversion in the induc-

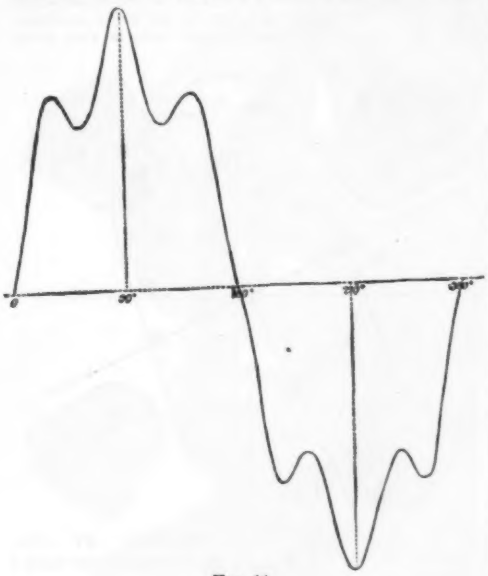


Fig. 11.

tive action to take place at about 25° from the position nearest the poles.

Fig. 4 is a sketch of the main parts of Isenbeck's instrument, and shows the small coil mounted on the wooden ring, and capable of being vibrated to and fro between stops. When vibrated at 0°, or in a position on the diametral line at right angles to the polar diameter, there is no induction in the coil; but as the coil is moved into successive positions round the ring toward the poles, and vibrated there, the induction is observed first to increase, then die away, then begin again in a very powerful way, as it nears the pole, where the rate of cutting the lines of force is a maximum. This powerful induction near the poles is, however, confined to the narrow region within about 12° on each side of the pole. It is beyond these points that the false inductions occur, giving rise in the coil, as it passes through the regions beyond the 12°, to electromotive forces opposing those which are generated in the regions which are close to the poles.

These inverse inductions were found by Isenbeck to be even worse when an iron disk, or an internal opposing magnet, was placed within the ring; but a re-enforcing magnet slightly improved matters. Of course such an action in a Gramme armature going on in all the coils, except in those within 12° of the central line of the poles, would be most disastrous to the working of the machine; and the rise of potential round the collector would be anything but regular. In Fig. 5 I have copied out Isenbeck's curve of induction for the consecutive four quadrants. From 0° to 90° the

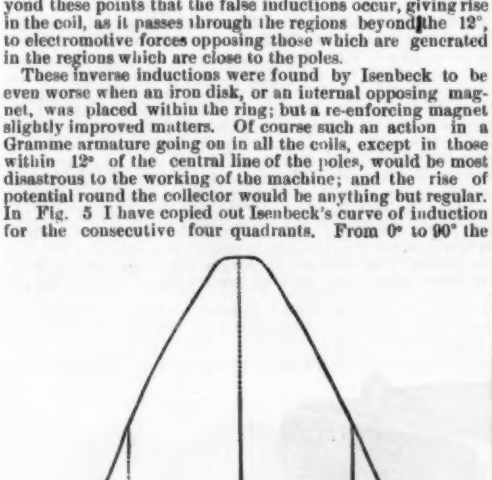


Fig. 12.

exploring coil is supposed to be vibrated in successive positions from the place where, in the actual dynamo, the negative brush would be, round to a point opposite the S pole of the pointed field-magnet. From 90° to 180° it is passing round to the positive brush; from 180° to 270° it passes to a point opposite the N pole; and from 270° to 360° returns to the negative brush. Now, since the height of this curve, at any point, measures the induction going on in a typical section as it moves through the corresponding region of the field, and since in the actual Pacinotti or Gramme ring the sections are connected all the way round the ring, it follows that the actual potential at any point in the series of sections will be got by adding up the total induced electromotive force up to that point. In other words, we must integrate the curve to obtain the corresponding curve of potential corresponding with the actual state of things round the collector of the machine. Fig. 6 gives the curve as integrated expressly for me from Fig. 5 by the aid of the very ingenious curve integrator of Mr. C. Vernon Boys. The height of the ordinate of this second curve at any point is proportional to the total area inclosed under the first curve up to the corresponding point. Thus the height at 90° in the second curve is proportional to the total area up to 90° below the first curve. And it will be noticed that though the induction (first curve, Fig. 5) decreases after 90°, and falls to zero at about 102°, the sum of the potentials (second curve, Fig. 6) goes on increasing up to 102°, where it is a maximum, and after that falls off, because, as the first curve shows, there is from that point onward till 180° an opposing false induction. If this potential curve were actually observed on any dynamo, we might be sure that we could get a higher electromotive force by moving the brush from 108° to 102°, or to 258°, where the potential is higher. Any dynamo in which the curve of potentials at the commutator presented such irregularities as Fig. 6, would be a very inefficient machine, and would probably spark terribly at the collector. The form and distribution of the magnetic force in the field are shown in Fig. 7, together with the exploring coil situated as in Fig. 4.

A simple inspection of the figure will show that at 6° a certain number of lines of force would thread themselves through the exploring coil. As the coil moved round to-

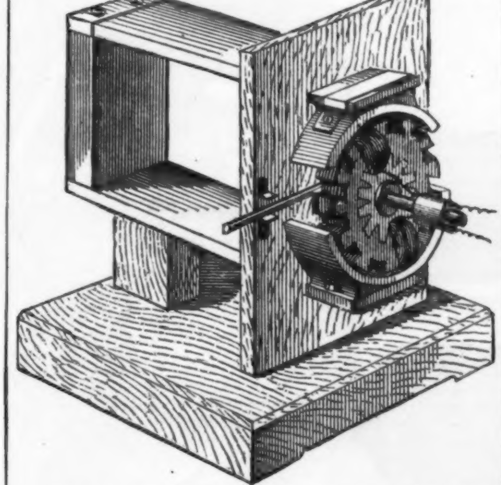


Fig. 13.—APPARATUS FOR INVESTIGATING INDUCTION OF ARMATURES.

ward the S pole, the number would increase at first, then become for an instant stationary, with neither increase nor decrease; after that a very rapid decrease would set in, which, as the coil passed the 90° point, would result in there being no lines of force through the coil. But at the very same instant the lines of force would begin to crowd in on the other side of the coil, and the number so threaded through negatively would increase until the coil turned round to about the position marked T, where the lines of force are nearly tangential to its path, and here the inversion would occur, because, from that point onward to 180°, the number of lines of force threaded through the coil would decrease. We see then that such inversions in the induction must occur of necessity to a small coil rotating in a magnetic field in which the lines of force are distributed in the curved directions, and with the unequal density which this disposition of the field-magnets presents. The remedy is obvious; arrange a more uniform field, in which the lines of force are more equally distributed, and are straighter.

If an iron core be substituted for the wooden core, the useful induction is greater, and the false induction less; there is still an inversion, but it takes place at about 25° from the pole, and is quite trifling in amount. The introduction of iron pole-pieces extending in two nearly semicircular arcs from the magnets on either side has, if the wooden ring be still kept as a core, the effect of completely changing the induction, so that the curve instead of showing a maximum at 90° from starting, shows one at about 10°, and another at 170°! If, however, we make the double improvement of using the iron pole-pieces and the iron core at the same time, the effect is at once changed. There are no longer any in-

Figs. 14 and 15.—EXPERIMENTAL ARMATURE.

versions, though the induction shows some peculiarity still. Fig. 8 shows the curve of induction adapted from Dr. Isenbeck's paper, and Fig. 9 the curve of potential, which I have had integrated from it. Looking at Fig. 8, we see that on starting from 0° induction soon mounts up, and becomes a maximum at about 20°, where the coil is getting well opposite the end of the encircling pole-pieces. From this point on, though the induction is somewhat less, it still has a high value, showing a slight momentary increase as the coil passes the pole at 90°, and there is another maximum at about 160°, as the coil passes the other end of the pole-pieces. My integrated curve (Fig. 9) tells us what would go on at the collector, if this were the action in the connected set of coils of a Pacinotti or Gramme ring. The potential rises from 0° all the way to close upon 180°. Still, this is not perfect. In the perfect case the potential curve would rise in a perfect harmonic wave form, like that shown in Fig. 2. Fig. 9 departs widely from this, for it is convex from 0° to 90°, and concave between 90° and 180°. But there are no inversions. The cause of the improvement is easily told; the field—such as there is between the pole-piece and the core—is "straighter," and the density of the lines of force in it more uniform. I proved this experimentally in 1878, by the simple process of examining the lines of force in such a field by means of iron filings; the actual filings, secured in their places upon a sheet of gummed glass, were sent to the late Mons. Alfred Niaudet, who had requested me to examine the matter for him. Fig. 10 shows the actual field between the encircling pole-pieces and the iron ring. It will be seen that though nearly straight in the narrow intervening region, they are not equally distributed, being slightly denser opposite the ends of the pole-pieces. One other case examined by Dr. Isenbeck we will glance at. The effect of introducing within the ring an interior magnet, having its S pole opposite the external S pole, and its N pole opposite the external N pole, was found to assist the action. The induction curve is represented in Fig. 11. As will be seen, there are two maxima at points a little beyond the ends of the pole-pieces, as before; but in between them there is a still higher maximum, right between the poles. This case also has been integrated on Mr. Boys' machine, and shows the potential curve of Fig. 12. This curve is a still nearer approach to the harmonic wave-form, being concave from 0° to 90°, and convex from 90° to 180°.

I pass from Dr. Isenbeck's researches, and the integrated

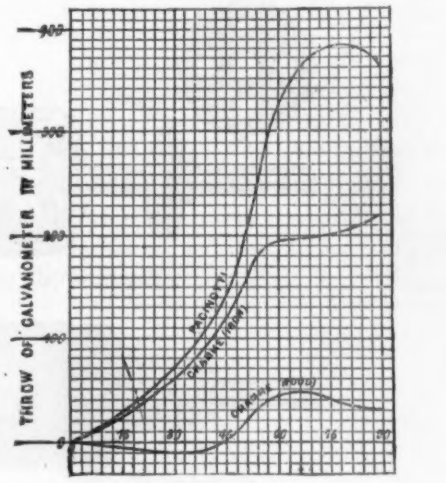


Fig. 16.

curves of potential which I have deduced from them, to some further researches of my own, which were undertaken with the view of throwing some light on the question whether the Pacinotti form of armature, in which the iron core is entirely overwound with wire, is the better. It has been assumed without, so far as I am aware, any reason assigned, that the Gramme ring was an improvement on that of Pacinotti. Pacinotti's was of solid iron, with teeth which projected both outward and inward, having the coils wound between. Gramme's was made "either out of one piece of iron, or of a bundle of iron wires," and had the coils wound "round the entire surface." Now, the question whether the Gramme construction is better than the Pacinotti or not, can readily be tested by experiment. And experiment alone can determine whether it is better to keep a thickness of wire always between pole-pieces and the core, or to intensify the field by giving to the lines of force the powerful re-enforcement of protruding teeth of iron. The apparatus I have constructed for determining this point is now before you. It is sketched in Fig. 13.

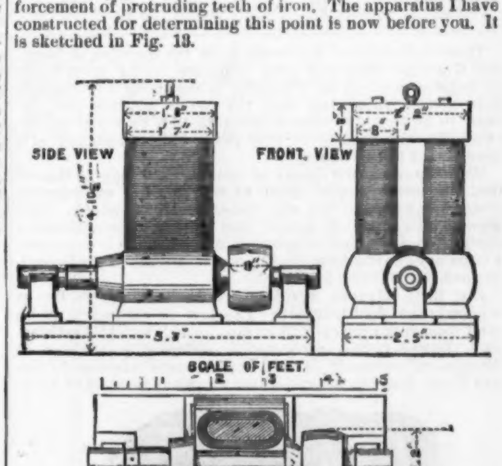


Fig. 17.—EDISON-HOPKINSON DYNAMO.

First, there are a couple of magnets set in a frame so as to give us a magnetic field, and there are pole-pieces that can be removed at will; in fact, there are three sets of pole-pieces for experimenting with different forms. Between the poles is set an axis of brass, upon which the armatures can be slid. These armatures are three in number. One is shown in Figs. 14 and 15, and consists of two coils of fine wire wound upon a wooden ring; another armature is exactly like this, but is built up on a ring of iron wire; a third (shown in its place in Fig. 13) is constructed upon a toothed ring made up of a number of plates of ferrotype iron cut out and placed flat upon one another. On each of the armatures are wound two coils at opposite ends of a diameter. The coils contain precisely equal lengths of silk-covered copper wire, cut from one piece. The cross section of the core within each of these coils is in each case a square, of one centimeter in the side, so that the number of turns in each coil is as nearly equal as possible. I can slip any one of these armatures into the field, and connect it with a galvanometer. There is a lever handle screwed to the arma-

ture, by means of which it can be moved. I have used two methods of proceeding, in order to compare the coils. One of these methods is to turn the armature suddenly through a quarter of a revolution, so that the coils advance from 0° to 90°, when the "throw" of the needle of the galvanometer—which is a slow-beat one—gives me a measure of the total amount of induction in the armature. The results are as follows:

GRAMME. Wooden Ring.	GRAMME. Iron Ring.	PACINOTTI. Iron Toothed Ring.
5	24	50

My second method of using these armatures consists in jerking the coils through a distance equal to their own thickness the coils being successively placed at different positions in the field; the throw of the galvanometer being observed as before. Each of the coils occupies as nearly as possible 15° of angular breadth. Accordingly, I have two stops set, limiting the motion of the handle to that amount, and at the back there is a graduated circle enabling me to set the armature with the coils in any desired position. If we move the coils by six such jerks, through their own angular breadth each time, then, starting at 0°, the sixth jerk will bring us to 90°. I have plotted out in Fig. 16 the three curves thus obtained, and the corresponding numbers are given in the following table:

	GRAMME.	GRAMME.	PACINOTTI.
	Wooden Ring.	Iron Ring.	Iron Toothed Ring.
0°-15°	5	25	30
15°-30°	10	60	70
30°-45°	0	120	140
45°-60°	45	195	320
60°-75°	40	200	380
75°-90°	30	220	360

These figures leave no doubt as to the question at issue. The Gramme pattern of ring armature, so far from being an improvement on the Pacinotti, is distinctly a retrograde step; always supposing that the cost of construction, liability to heating, and other kindred matters be equal for the two. The significance of this point will be resumed at a later period in this paper.

Before leaving the theory of armatures, to pass to that of field magnets I should wish to say that the experiments which I have made, and also those of Dr. Isenbeck, have been so instructive to myself, that I have already begun a similar series of observations on other forms of armature. I hope in due time to make known the results of my investigations.

But little advance has been made in theory so far as relates to the field magnets. The law of saturation of an electro-magnet remains still an empirical law. It is satisfactory, however, that such widely differing authorities as Professor Clausius, M. Marcel Deprez, and Professors Ayrton and Perry agree in accepting the emprical formula of Fröhlich as a sufficiently accurate expression of the law of saturation.

Some progress has been made in the theory of the lead that must be given to the brushes of the dynamo. Formerly this was ascribed to a sluggishness in the demagnetization of the iron of the armature; but in 1878, the late M. Antoine Breguet suggested as a reason the influence of the actual current circulating round the armature coils, which would tend to produce in the iron of the armature a magnetization at right angles to that due to the field magnets.

Breguet showed that there would be a resultant oblique direction of the lines of magnetization in the field, and therefore, since the "diameter of commutation" is at right angles to this direction, the brushes also must be displaced through an equal angle. Clausius accepts this view in his recent theory, and adopts for the angle of the resultant field that whose tangent is the ratio of the two magnetizing forces due to the field magnets and the current in the armature respectively. Professors Ayrton and Perry have also pointed out that there will be an additional displacement of the resultant pole of the armature, consequent upon the self-induction going on in the armature coil between its different sections. In their paper on the government of motors, in which they have brought out this point, they, however, take the view that part of the displacement of the pole is due to the sluggishness of demagnetization of the iron. I do not think, however, that this can be maintained. No experimental proof has ever been given that there is any such thing as a true magnetic lag; the apparent magnetic sluggishness of thick masses of iron is demonstrably due to internal induced currents; and no one uses solid iron in armature cores for this very reason. Neither has it been shown that thin iron plates or wires, such as are used in armature cores, are slower in demagnetizing than magnetizing. Indeed, the reverse is probably true; and, until further experimental evidence is forthcoming, I shall assume that there is no magnetic lag in properly laminated iron cores.

It may here be pointed out that, assuming as a first approximation that the rule that the tangent of the angle of lead represents the ratio between the magnetizing power of the field magnets and of the armature coils, the lead may be diminished to a very small quantity, by increasing the ralative power of the field magnets, a course which is for many reasons advisable. All practice confirms the rule that the magnetic moment of the field magnets ought to be very great as compared with that of the armature. Further than this, there ought to be so much iron in the armature as to be just saturated when the dynamo is working at its greatest activity. If there is less than this, it will become saturated at a certain point, and when any currents greater than this are employed, the lead will alter, for then the magnetic effect due to the current in the armature will be of greater importance, relatively to that due to the field magnets. For the same reason, the lead will be more constant when the field magnets are under their saturation point than when quite saturated. In short, every cause that tends to reduce the lead makes the lead more constant, and therefore tends to reduce sparking at the brushes. And the best means to secure this is obviously to use an unstinted quantity of iron—and that of the softest kind—both in the field magnets and in the armature, for then the currents circulating in the armature will have less chance of perturbing the field.

In relation to the magnetization of field magnets, it may be pointed out that the "characteristic" curves, now so much used for the study of the action of dynamo machines, which show the rise of the electromotive force of the machine in relation to the corresponding strength of the current, are sometimes assumed, though not quite rightly, to represent the rise of magnetization of the field magnets. Now, though the magnetization of the magnet may attain to practical saturation, it does not, under a still more powerful current, show a magnetization less than saturation. But the characteristics of nearly all series-wound dynamos show—at least, for high speeds—a decided tendency to turn down after attaining a maximum; and for some machines, for example the Brush, this diminution of the electromotive force is very marked. The electromotive force diminishes, but the magnetism of the field magnets does not. An explanation of this dip in the characteristic has lately been put forward by Dr. Hopkinson, in his lecture on "Electric Lighting," before the Institution of Civil Engineers, attributing this to the reaction of self-induction and mutual induction between the sections of the armature. No doubt this cause contributes to the effect, as all such reactions diminish the electromotive force. I am inclined, however, to think that the greater part of the effect is due to the shifting of the effective line of the field in consequence of the iron of the field magnets becoming saturated before the armature is so. It is at least significant that in the Brush machine, where the reduction of electromotive force is very great, there is also such a mass of iron in the armature, and so variable a lead at the brushes.

Another point in which theory has for long been ahead of practice, is in the advantage to be gained by working as nearly as possible with closed magnetic circuits; that is to say, with a nearly continuous circuit of iron to conduct the lines of magnetic force round into themselves in closed curves. The enormous importance of this was pointed out so far back as 1878 by Lord Elphinstone and Mr. C. W. Vincent, whose dynamo embodies their idea. Every electrician knows that if a current of electricity has to pass through a circuit, part of which consists of copper and part of liquids—such as the acid in a battery or the solution in an electrolytic cell—the resistance of the liquid is, as a rule, much more serious than the resistance of the copper. Even with dilute sulphuric acid the resistance to the flow of the current by a thin stratum is 200.000 times as great as would be offered by an equally thick stratum of copper. And in the analogous case of using a field-magnet to magnetize the iron core of an amature, the stratum of air—or, it may be, of copper wire—in between the two pieces of iron offers what we may term a relatively enormous resistance to the magnetic induction. If we take the magnetic permeability of iron as 1, then the permeability of air is something like $\frac{1}{20000}$, and that of copper is not very different, or in other words, a stratum of air or copper offers about 20,000 times as much resistance to the magnetic induction as if the space were filled up with soft iron. Obviously, then, it would be a gain to diminish as much as possible the gaps between the portions of iron in the circuit. The values of the magnetic permeability for iron, air, and copper have been known for years, yet this simple

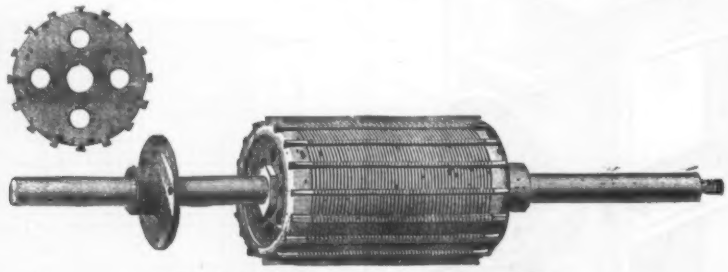


FIG. 18.—CORE OF WESTON ARMATURE.

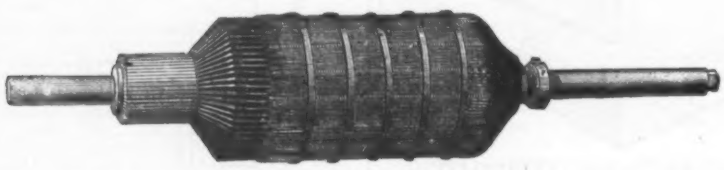


FIG. 19.—WESTON ARMATURE.

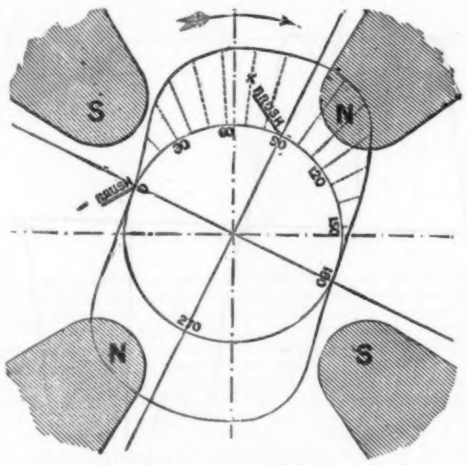


FIG. 22.—DIAGRAM OF POTENTIALS AT COLLECTOR OF 4 POLE SCHUCKERT-MORDEY DYNAMO.

FIG. 20.—WESTON DYNAMO.

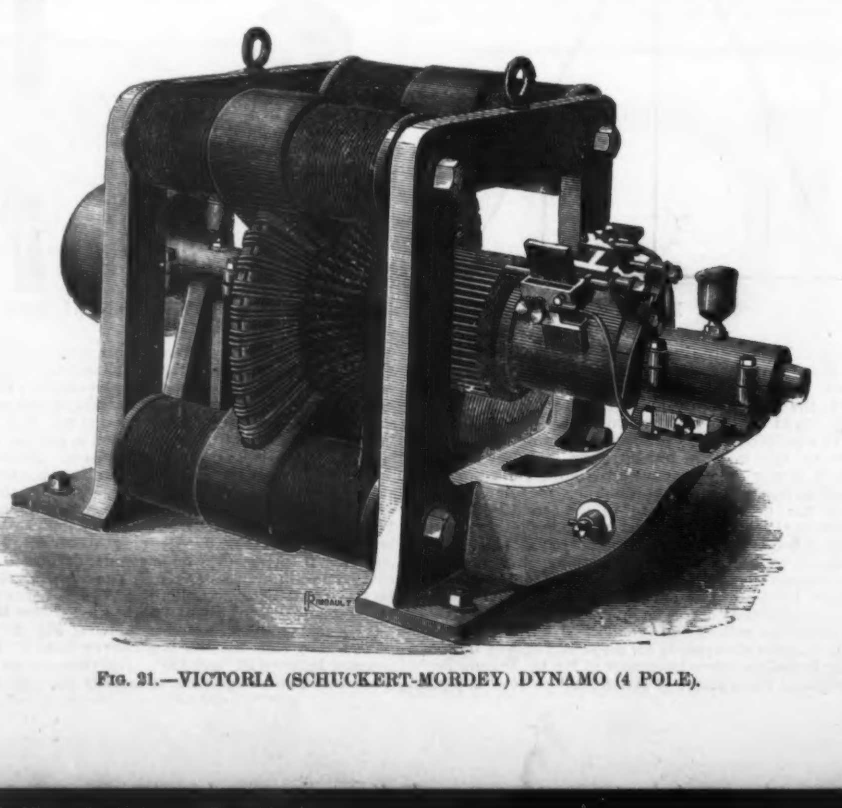


FIG. 21.—VICTORIA (SCHUCKERT-MORDEY) DYNAMO (4 POLE).

deduction from theory has been set at defiance in the vast majority of cases. We have had, a few minutes ago, an experimental proof that the Pacinotti ring, so far from having been "perfected" or "improved" by Gramme, as some very high authorities say, is vastly inferior to it. It will perhaps be intelligible now why Pacinotti's design was essentially right.

I now pass on to the progress recently made in the practical construction of dynamo-electric machines. Thanks to the kindness of several of those by whom this progress has been achieved, I am able to put before you their very latest results.

The Edison dynamo has, during the past eighteen months, received very material improvements at the hands of Dr. Hopkinson, F.R.S. Some of these improvements relate to

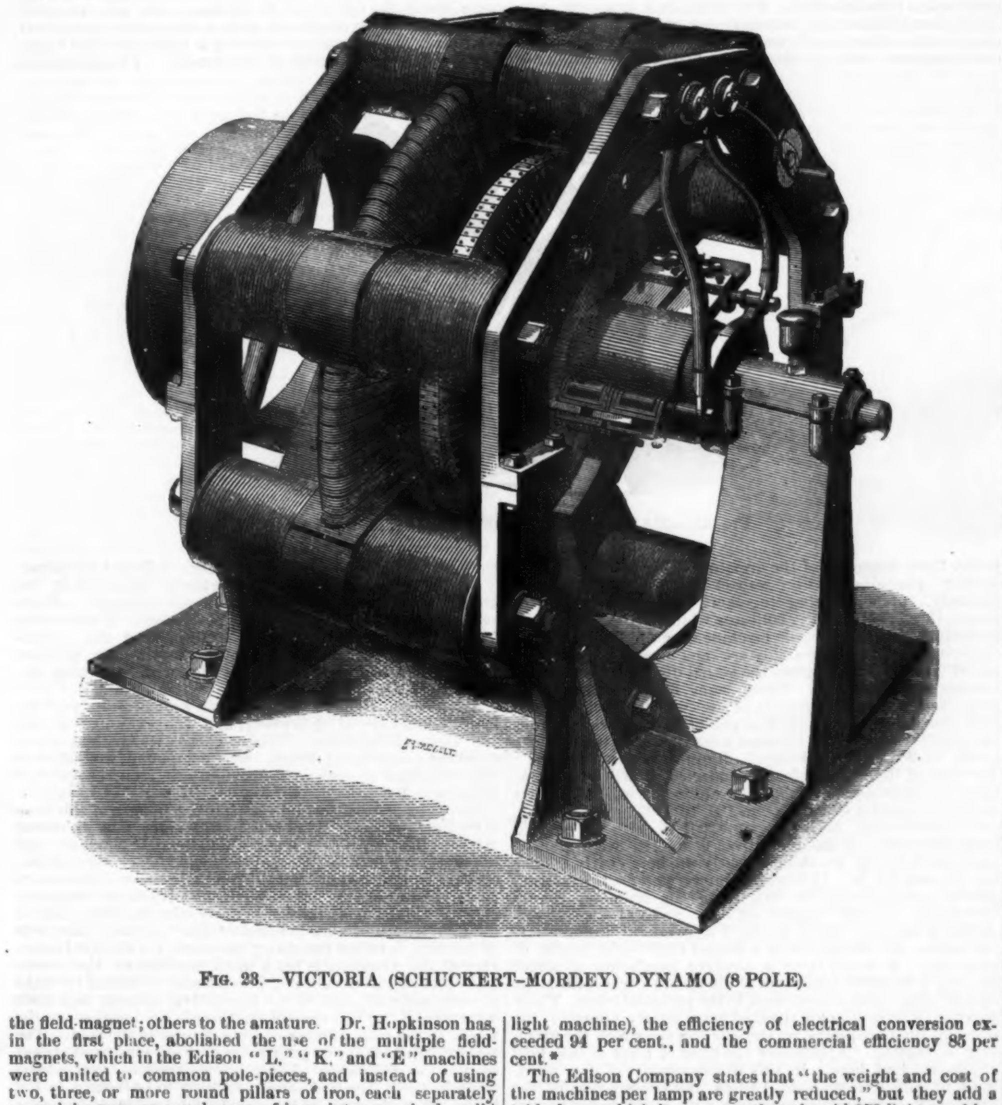


FIG. 23.—VICTORIA (SCHUCKERT-MORDEY) DYNAMO (8 POLE).

the field-magnet; others to the amature. Dr. Hopkinson has, in the first place, abolished the use of the multiple field-magnets, which in the Edison "L," "K," and "E" machines were united to common pole-pieces, and instead of using two, three, or more round pillars of iron, each separately wound, he puts an equal mass of iron into one single solid piece of much greater area of cross-section and somewhat shorter length. One such iron mass, usually oval or oblong cross-section, is attached solidly to each pole-piece, and the two are united at the top by a still heavier yoke of iron. The machines have, consequently, a more square and compact appearance than before (Fig. 17). It may be remarked, in passing, that the use of multiple pillars of iron used by Edison in the "L," "K," and "E" machines must have been prejudicial, because the current in those portions of the coils which passed between two adjacent iron pillars must have been opposing each other's magnetizing effect. Dr. Hopkinson has also introduced the improvement of winding the mag-

FIG. 24.—CABELLA ARMATURE.

nets with a copper wire of square section, wrapped in isulated tape. This wire packs more closeiy round the iron cores than an ordinary round wire In the armature the following change has been made. The iron core in the older Edison machines was made of thin iron disks separated by paper slipped on over a sleeve of *lignum vitæ*, and held together by six longitudinal bolts passing through holes in the core-plates, and secured by nuts to end plates. These bolts are now removed, and the plates are held together by great washers, running upon screws cut on the axle of the armature. The size of the central hole in the plates has been diminished, thus getting into the interior more iron, and providing a greater cross-section for the magnetic induction. By these improvements, a machine occupying the same ground space, and of about the same weight as one of the older "L" 150-light machines, is able to supply 250 lights, the efficiency being at the same time improved. In the new 250 light machine, the diameter of the armature is 10 inches; its resistance, cold, is 0·02 ohm; that of the magnets is 17 ohms. The characteristic curve of the machine shows that even when doing full duty the field-magnets are far from being saturated. It will be remarked that, in the older construction, the bolts and their attached end-plates furnished a circuit in which idle currents were constantly running wastefully round, with consequent heating and loss. An Edison 60-light "Z" machine of the older pattern, tested by the committee of the Munich Exhibition, was found to give an efficiency which, if measured by the ratio of external electric work to total electric work, exceeded 87 per cent.; but its commercial efficiency—the ratio of external electric work to the mechanical energy imparted at the belt—was only, at the most, 58·7 per cent. In a recent test made by Mr. Sprague, at Manchester, on an improved dynamo (a 200-light machine), the efficiency of electrical conversion exceeded 94 per cent., and the commercial efficiency 85 per cent.*

The Edison Company states that "the weight and cost of the machines per lamp are greatly reduced," but they add a table from which it appears that the old 250-light machine costs £250, while the new 250-light machine costs £265, if made as a fast speed machine, and £425 if constructed as a slow-speed machine.

The Siemens machines have not been much altered during the past year, and it is a little difficult to describe the improvements which have been made, as the firm of Siemens Bros. decline, for commercial reasons, to furnish data for publication. Progress has, however, been made by this firm, especially with their compound wound machines, of which some account has been given by Herr E. Richter, in the *Electrotechnische Zeitschrift*. It appears that three methods

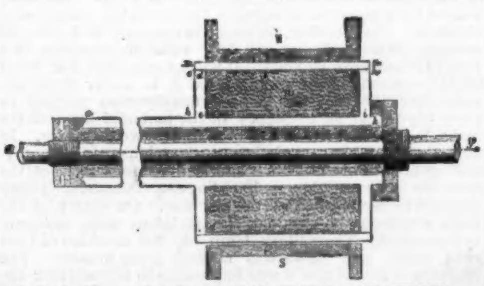


FIG. 25.—CABELLA ARMATURE.—SECTION.

of combination have been tried. The shunt and series coils have been wound on different arms of the magnets; they have been wound on separate short frames, and slipped on to the cores side by side; and they have been also wound over one another. In the latest machines, the series coils are wound outside the shunt windings. The regulation, judging by the curves given by Herr Richter, is not perfect. The best regulation was from a "*g* D 17" machine, of which two of the magnet limbs were wound with shunt coils of 29 layers of a 1 millimeter wire, and the other two with two layers of a 3·5 millimeter wire. The potential varied from 64 to 69 volts when the number of lamps was reduced from 20 to 9.

The Weston machine has an armature more or less resembling those of the Siemens machines. The core is built up of disks of iron, of the form shown in Fig. 18, strung together, and presenting projecting teeth all along the surface of the cylinder. Fig. 19 shows the armature when completed. In this machine, as is also evident from Fig. 20, the pole-pieces are laminated, to obviate eddy currents and heating. Recently, Mr. Weston has adopted a method of winding the armature with two circuits, so that an accident to one section shall not completely break down the machine. The latest of the Weston machines show substantial design and many improvements in detail upon the older forms.

The machines of the Gramme type next come in for consideration. In those of the actual Gramme pattern I cannot learn that any important improvement has been made in this country; but in the States, the Fuller Electrical Company, which holds the Gramme and Wood patents, has brought out several improved forms of machine in which mechanical

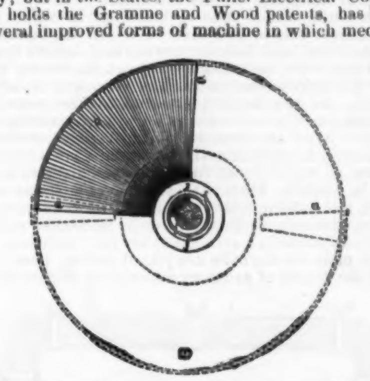


FIG. 26.—ARMATURE OF SIR W. THOMSON'S WHEEL DYNAMO.

engineering skill of a high order is apparent. The field magnets, frames, and pole pieces are very substantial, the ring is better built than the European types, and the collector bars are prevented from flying to pieces by the addition of an insulated ring shrunk on over their ends. In France, too, the machine has received important modifications at

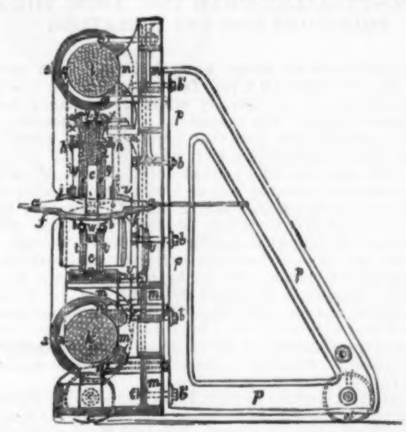


FIG. 27.—SIR W. THOMSON'S WHEEL DYNAMO. VERTICAL SECTION.

the hands of M. Marcel Deprez. M. Deprez's dynamo has two Gramme rings upon one axle, which lies between the poles of two opposing field-magnets, each of the two-branched, or so called horseshoe, form. These are laid horizontally, so that the north pole of one is opposite the south pole of the other, and *vice versa;* the poles being provided with curved pole-pieces between which the rings revolve. M. Deprez, who has given much attention to the question

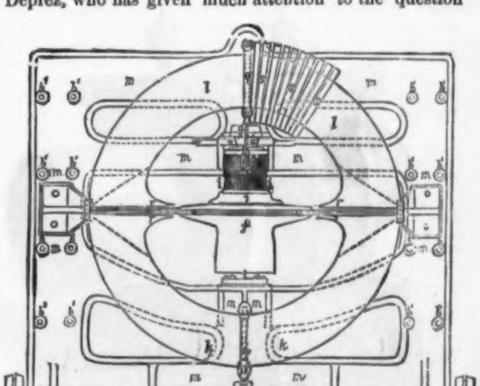


FIG. 28.—SIR W. THOMSON'S WHEEL DYNAMO. FRONT ELEVATION.

how to design a machine which, with the least expenditure of electric energy, gives the greatest actual couple at the axle, is of opinion that the horseshoe form of electro-magnet is the most advantageous. The iron cores and yokes of the field-magnets are very substantial; but the pole-pieces are not very heavy. M. Deprez's machine has a very elaborate system of sectional windings of the field-magnets and a switch-board, enabling him to couple up the connections in various ways. The circuits of the two rings are quite distinct, and each armature has its own collector and brushes. M. Deprez has also constructed other Gramme machines, with armatures of very fine wire, for his experiments on the electric transmission of power.

Another machine, having as an armature an elongated ring somewhat like that of the Maxim dynamo, was shown during last autumn at the Fisheries Exhibition, under the name of the Hockhausen dynamo. The field-magnets of this machine are very strangely disposed, the ring being placed be-

* These values assume the B. A. unit as the true ohm, and are therefore probably about 1¼ per cent. too high.

tween two straight electro-magnets placed vertically over one another; the upper magnet being held in its place by curved flanking pieces of iron, which run down the two sides of the machine, and connect the topmost point of the upper magnet with the lowest part of the lower. This arrangement, which strikes the eye as being both mechanically and magnetically bad, is claimed as one of the virtues of the machine, which, in spite of its magnets, appears to be a very good working machine. Its armature is constructed of four separate curved iron frames, upon which the previously wound coils are slipped, and which are then bolted together and secured to strong end plates. I have not seen any report on the efficiency of this machine.

We next come to the class of machines in which a flattened Gramme ring is used, and of which the machines of Fein, Schuckert, and Gülcher are the best known types.

Mr. Gülcher has been steadily at work improving his dynamo in its various mechanical and electrical details. In particular, he has devoted attention to the winding of the field-magnets, so as to secure a constant potential at the terminals. After experimenting with various methods of compounding, he finds that the best results are arrived at in the following way: In his four-pole dynamo there are eight cores to be wound. Each of these receives a shunt coil of fine wire, and outside this is a main coil of stout wire. The eight fine wire coils are then joined up in series with one another, and connected as a shunt to the terminals; while the eight main circuit coils are joined up in parallel. In proof of the degree of accuracy attained by this method Mr.

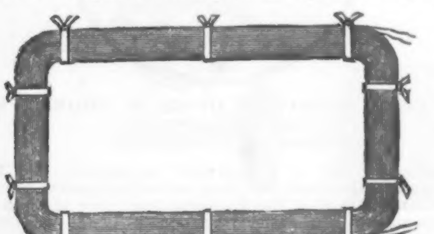


FIG. 29.—PARALLELOGRAM COIL FROM THE ELPHINSTONE-VINCENT ARMATURE.

Gülcher has given me many numerical data from actual tests. All of them show a very fair approximation to a constant potential, and an actually attained constancy for a considerable range. For example, a four-pole machine, intended to give 65 volts, gave that figure exactly, when the external current varied from 30 to 88 amperes; and gave 64 volts at 105 amperes, 63·5 volts at 130 amperes. With one ampere only, the potential was 61·5 volts. Mr. Gülcher adds that, in spite of all possible care in manufacture, very large machines do not give results as satisfactory as those given by machines of somewhat smaller dimensions, though the machines are of identical type, and their parts calculated from the same formulæ. He thinks this to indicate that to obtain the same ratio of output and efficiency to weight, there ought to be a corresponding increase made in the electromotive force of the machine. In other words, the means taken in large machines to keep down the electromotive force to equality with that of the smaller machines are detrimental to the action of the machine.

The Anglo-American Electric Light Corporation has been manufacturing during the past year a dynamo of the flat-ring type, under the patents of Schuckert and Mordey, to which the not very apt name of the "Victoria" dynamo has been given. By the kindness of Mr. F. Wynne, general manager of the corporation, and of Mr. Mordey and Mr. P. Sellon, I have been able to learn a great deal about this machine, and to test personally its capabilities. There are two types of the new Schuckert-Mordey dynamo, one having four, the other eight poles arranged round the ring. As mentioned earlier in this paper, Mr. Mordey has given great attention to the form of the pole-pieces. These pole-pieces, in the earlier Schuckert machines, consisted of hollow iron shoes

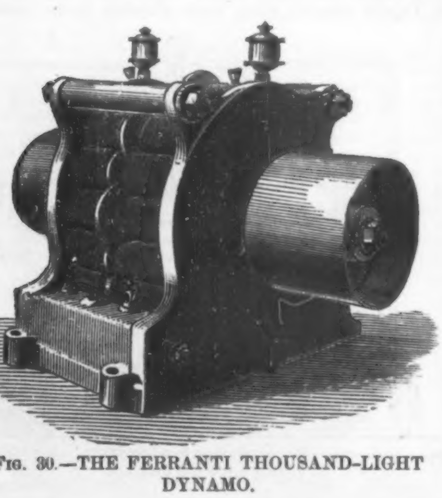


FIG. 30.—THE FERRANTI THOUSAND-LIGHT DYNAMO.

or cases which occupied a large angular breadth along the circumference of the ring. Similar hollow polar extensions are still used in the Gülcher machines (see Fig. 26 of my Cantor lectures). Mr. Mordey has found my opinion, based upon the diagrams of potential at the collector, to be correct, that these wide-embracing pole-pieces were responsible for false inductions, giving rise to opposing electromotive forces and setting up secondary neutral points at the collectors. He has, therefore, by long extended experiments, arrived at a form of pole-piece which completely obviates these effects. As will be seen from Fig. 21, which represents the four-pole Victoria dynamo, the pole-pieces, though they embrace the ring through its whole depth, from external to internal periphery, are quite narrow, and do not cover more than 30° of angular breadth of the circumference of the armature. They are of cast iron, and are cast upon the cylindrical cores of soft wrought iron which receive the coils. It may be mentioned that, in the four-pole Gülcher machines, the wide box-like pole-pieces are also cast on wrought-iron cores. The armature of the Victoria dynamo resembles in its structure the Pacinotti rather than that of the Gramme type. Its core is built up of rings cut from sheet charcoal iron, and Mr. Mordey has taken special pains to insure that there are no electric circuits made in the bolting together of these cores, each plate being both electrically and magnetically insulated from the adjacent plates. Eddy currents in the core are thus almost entirely obviated. This was far from being the case with some of the earlier machines, in which, as in the Edison machine until Dr. Hopkinson improved it, the bolts holding together the cores constituted an available path for wasteful inductions. The core rings of the Victoria dynamo are toothed, as in the Pacinotti ring, and the wires are wound in the intervening gaps. There is, moreover, ample ventilation in this armature, a point not to be overlooked. Formerly, in a four-pole machine, four brushes were necessary—as in the Gülcher dynamo and the four-pole Gramme. Mr. Mordey has reduced the number to two, by the device, first, of connecting together those segments of the armature coils which occupy similar positions, with respect to the poles; and secondly, of connecting together, by metallic connections, those bars of the collector which are at the same potential. In the four-pole machine opposite bars are thus connected. Two brushes only are then necessary, and these are 90° apart. Fig. 22 gives the actual diagram of the potentials at the collector. There being 60 sections in the ring, there will be 15 segments of the collector from the negative brush to the positive. The potential rises steadily from the negative brush, and becomes a maximum at the positive brush at 90°, whence it again diminishes to zero at 180°. The bars of the collector being connected, it will be remembered, to those diametrically opposite to them, it follows that the potential will rise from 180° to 270°, precisely as it rose from 0° to 90°, and will again fall to zero in passing from 270° to 0°. If the curve from 0° to 180° were plotted again horizontally, we should clearly see how nearly regular the rise and fall is. If from this curve we were to construct another one, in which the heights of the ordinates should correspond to the tangent of the angle of slope of this potential curve—in other words, if we were to differentiate the curve—we should obtain a second curve—the curve of induction. It would show a positive maximum at about 30°, and a negative maximum at about 120°, where the slope up and slope down are steepest in the potential curve. These maxima of induction are situated very nearly opposite the edges of the pole-pieces, on the side toward which the armature is rotating. Apparently the lines of force of the field are the thickest here. In this displacement of the maximum of induction we have, I think, the explanation of the inferiority of the earlier machines with broad polar expansions. In those machines the maximum position of induction was displaced to the very edge of the broad pole-piece, and therefore the induction was sudden and irregular. It is a singular result that while in those machines in which the ring armature is extended cylinderwise there must be wide embracing pole-pieces, in those in which the ring is flattened into a disk shape the pole-pieces must on no account be wide.

The Victoria dynamo is self-regulating, having all the eight field-magnet coils doubly wound, with main circuit coils inside, and shunt coils outside. The characteristic of this machine is wonderfully straight. In a "D^3" machine, wound for a potential of 60 volts, the following values were obtained: Open circuit, 58 volts; 10 amperes, 58·5 volts; 20 amperes, 59 volts; 60 amperes, 59·7 volts; 90 amperes, 59·9 volts; 120 amperes, 60 volts. It will be seen that for small loads the potential drops a little; but it is under these circumstances that the engine speed usually rises slightly in practice, so that the constancy of the potential between the mains is somewhat better than the figures would show. In actual practice, the regulation is marvelous. I have myself opened the circuit of a Victoria dynamo which at the time was feeding 101 lamps, 100 being at a distance, one lamp attached to the terminals of the machine. On detaching the main wire from the terminal, the 100 lamps were suddenly extinguished. The solitary lamp on the machine did not even wink, and there was no flash at the brushes. The sparking was so slight it was impossible to tell whether the machine was an open circuit or whether it was doing full work. The lead was the same under all loads. There are not many dynamos that can show a result of this kind. According to measurements made by the Anglo-American Corporation's electricians, who have published the figures entire, the factor of conversion of this machine is 96·15 per cent., the electrical efficiency 85·68 per cent. These values assume the B. A. unit of resistance as the true ohm, and are, therefore, probably about 1¼ per cent. too high. Some of these machines are wound for low speeds for ship lighting. These machines have an electrical activity slightly higher, and an efficiency slightly lower, than the high speed machines. They also have field-magnet cores slightly heavier, requiring, therefore, the expenditure of rather more electrical energy in maintaining the field. These remarks refer, of course, to a comparison between machines wound to light an equal number of lamps, and to work at an equal electromotive force.

A larger type of Victoria machine having eight poles, alternately north and south, set round the ring, has also been constructed by the Anglo-American Corporation. This machine (Fig. 23) illuminates 750 incandescent lamps. The ring has 120 sections, there being 15 sections, therefore, between each pole and the adjacent pole of the surrounding set. As each segment of the collector is connected with those situated at 90°, 180°, and 270° distance round the set, only two brushes are required.

A rather singular commentary upon the real superiority of multipolar dynamos having rings of the flattened type, over the more compact ring armatures to which we have been accustomed in the ordinary Gramme machines, is furnished by the announcement within the past month of a new and improved dynamo designed by M. Gramme himself, in which there is a flat-ring armature rotating within a crown of 12 poles. Elaborate illustrations and a detailed description of this latest of dynamos are given in the *Revue Industrielle* of January 9, 1884. From this article it appears that in the opinion of M. Gramme the new machine still requires some modifications to make it quite a practical machine. A glance at this drawing is quite sufficient to enable one to hazard a guess at the reasons. The pole-pieces

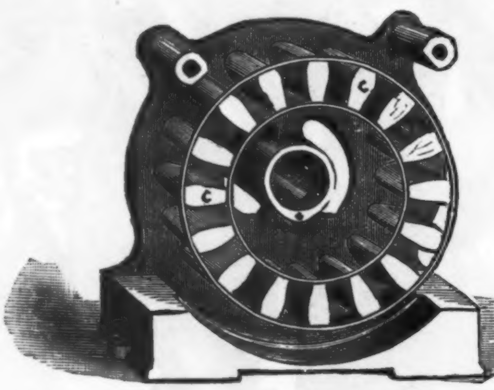


FIG. 31.—HALF-CARCASS OF FERRANTI DYNAMO.

are broad, nearly meeting one another. I should confidently predict from such a design the vice of sparking at the brushes and heating of the collector segments. Moreover, there are no fewer than 24 brushes! Think of the friction of 24 brushes, and the labor of making the complicated holders! It appears that in England we are at least a few steps ahead of France in the matter of designing dynamo machines.

Another four-pole flat ring dynamo has been designed by Herr Schuckert, of Nürnberg, and was exhibited at the late Vienna Exhibition. This machine, which had many excellent points in its design, was compound wound, and was calculated to give, at 450 revolutions, a current of 320 amperes at 100 volts.

The present drift toward multipolar dynamos of this type is very significant. There is little difference save in detail between the four-pole machines of Gülcher, Schuckert, and the newer "Schuckert-Mordey" dynamo, albeit these differences are not unimportant. But all these constructors agree in adopting the flat-ring. The advantage originally claimed for this construction, namely, that it allows less of the total length of wire to remain "idle" on the inner side of the ring, is rather imaginary than real, for the total resistance of the armature is but a small fraction of the whole resistance of the circuit; and it is possible to spread the field so as to make all parts of the wire active without any gain whatever, if, by this spreading, there is no increase on the whole in the total number of lines of force in the field. The real reasons in favor of multipolar flat-ring armatures appear to be the following: First, their excellent ventilation; second, their freedom from liability to be injured by the flying out of the coils by the tangential inertia (often miscalled centrifugal force) at high speeds; third, their low resistance, due to the fact that the separate sections are cross connected either at the brushes, or in the ring itself, in parallel arc. To these may be added that, with an equal peripheral speed, the armature rotating between four poles

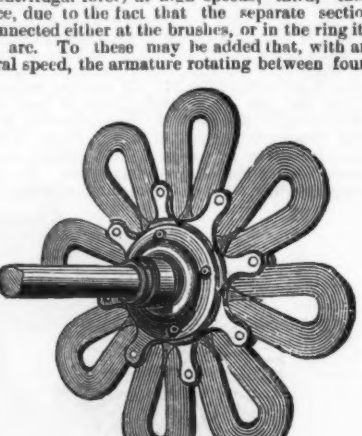


FIG. 32.—FERRANTI ARMATURE.

undergoes twice as much induction as when rotating between two poles; since it cuts the lines of force twice as many times in the former case as in the latter.

I pass on to the improvements made in the dynamo by Messrs. R. E. Crompton & Co. To describe the course of development which the Burgin dynamo has undergone in Mr. Crompton's hands would alone occupy a whole evening. The armature of the original machine, as it came from Switzerland, consisted of several rings set side by side on one spindle, these rings being made of iron wire wound upon a square frame, and carrying each four coils. In this form it is described in Professor Adams' Cantor lectures on "Electric Lighting" in 1881. Mr. Crompton changed the square form to a hexagon having six coils upon it, and increased the number of rings to ten, so that the armature consisted of sixty segments. He then found it advisable to alternate the positions of these, instead of placing them in a regular screw-order on the spindle, as shown in most of the

published drawings of this well-known machine. The next step was to increase the quantity of iron in the hexagonal cores, and to ascertain by experiment what was the best relative proportion of iron and copper to employ. At the same time Mr. Crompton and Mr. Kapp introduced their system of "compounding" the windings of the field-magnets. Another change in the armature followed, the rings being made much broader and fewer in number, four massive hexagonal rings, united to a 24-part collector, replacing the ten slighter rings and their 60-part collector. Quite recently Mr. Crompton and Mr. Kapp have again remodeled the style of armature, and have produced a machine which, though it is not yet quite completed, shows what may be done in the way of improvement by careful attention to the best proportions of parts and quality of material. The new dynamo weighs 22 cwt. Its field-magnets are of the very softest Swedish wrought iron, compound-wound. The armature is a single ring of the elongated or cylindrical pattern, and its coils are wound upon an iron core made up of toothed disks of very thin soft iron fixed upon a central spindle, the coil being wound between the teeth as in a Pacinotti ring. In fact, the armature may be described as a kind of cross between those of Weston and Pacinotti, having also something in common with the Burgin armature; at least, so I understand, for though I have, by the kindness of Mr. Crompton, been allowed to see the machine, I have had no opportunity as yet of examining the armature. Mr. Crompton's great aim has been to have as complete a magnetic circuit as possible, and that of the best quality. He has sought to increase the intensity of the field by having plenty of iron in the armature, and bringing that iron as close as possible into proximity with the pole-pieces by means of the projecting teeth. The result is an extraordinary increase in the "output," or, as Sir William Thomson terms it, "activity" (*i. e.*, amount of work done per second), of the machine. The machine is only 3 ft. 4 in. long, 12 in. high, and 2 ft. wide. The armature is 17 in. long, and 8 in. diameter. At 1,000 revolutions per minute it gives 110 amperes at 145 volts, or its "activity" is 15,950 watts; but at this speed it heats too much. The power of the field-magnets is such that, at all speeds, and under all conditions of the external circuit, the intensity of the field overmasters the magnetizing action of the currents in the armature coils. There is, therefore, hardly any lead at all at the brushes, and what lead there is, is absolutely constant. There is no sparking at the brushes, and it is impossible to tell by looking at the brushes whether the current is off or on. Mr. Crompton is now constructing another machine of the same general design, but larger, to drive 1,000 Swan lamps. This machine, together with its engine, is only about 8 ft. long, 6 ft. high, 2 ft. 4 in. wide, and complete, with its bed plate, will weigh only about 8 tons.

It may be mentioned that in Messrs. Crompton's compound dynamos, as also in those of the Anglo-American Corporation, the series coils are wound direct upon the iron cores, and the shunt coils outside them, thus reversing the practice adopted by Messrs. Siemens, and by Mr. Gülcher. It might have been expected that theory would have something to say in determining which practice is preferable. If the shunt coils of thin wire are outside, the prime cost for an equal magnetizing effect will probably be greater. If the series coils are outside, the loss by heating in producing an equal magnetic effect will probably be increased. It might have been expected that, as with galvanometer coils, so with the coils of field-magnets, it would be advantageous to get as many of the turns as close as possible to the core, and, therefore, that the thinner wire should be wound on before the thicker. But, on the other hand, it is advisable to keep down the resistance of the series coils, as they will form part of the main circuit, while the additional resistance necessitated by winding in coils of larger diameter is not altogether a disadvantage in a shunt coil. If this proves to be the right way of regarding the problem, we shall wind the shunt coils outside those that are in series with the main circuit.

Before leaving the subject of ring-armatures I should like to refer to a form recently devised by Signor B. Cabella, which I think might be recommended to amateur constructors of dynamos as being easily made. The Figs. 24 and 25 show its general arrangements. The armature resembles that of the Edison dynamo in being built up of copper strips. These are separately cut out, and consist each of a straight piece having two arms, and projecting at right angles. A sleeve of insulating material is placed over the axle, and round this these copper pieces are arranged to the number of some 240 or so, having their arms projecting symmetrically round in two radial sets, one near one end and the other near the other. The channel formed thus between the two sets is lined with insulating material, and then entirely filled up with soft iron wire wound round. Then straight strips of copper, eight millimeters broad and two millimeters thick, are screwed across the outside (like the bars of the Edison armature) from the ends of one set of radial projections to the ends of the others, forming the parallelogram section. But, in order to connect the ring all round in a continuous circuit, these external strips of copper are connected at their two ends to pieces which project not from the same internal copper strip but from adjacent strips. Thus an external bar will connect the anterior end of the first strip with the posterior end of the second, and so on. Every third strip is carried along the axle, and connected to a segment of the collector. This construction is certainly simpler than that of the Edison armature, and might be adapted to many different types of machines. According to Professor Ferrini, one of Cabella's armatures placed between the poles of a 60-light Edison ("Z," old pattern) instead of its ordinary armature, increased its power so that it could be used over 100 lamps.

Passing from ring-armatures, I come to another type of machine having disk armatures. The earliest machine of this type was due to the indefatigable Mr. Edison, who built up his disk of radial bars connected at the outer ends by concentric hoops, and at the inner by plates or washers. Each radial bar communicates with the one opposite to it, and the disk thus built up is rotated between the cheeks or pole-pieces of very powerful field-magnets, which very nearly meet, and which therefore yield an enormously powerful field. I cannot hear of any of these disk dynamos having yet come into practical use.

Another type of disk-dynamo has been invented by Sir W. Thomson. In this case, the armature is a flat wheel, very like a flattened bicycle wheel. It is shown at *a* in Figs. 26, 27, and 28. The radial arms or spokes of the wheel, in which the currents are induced, are all connected at their external ends to the copper rim, but at their internal ends are carefully insulated and connected each to a segment of a collector or commutator, *g*. As in Edison's disk machine, so also in this, the thin disk rotates between the poles of very powerful field-magnets, which, in the case of Sir W. Thomson's machine, are semicircular in form. Sir W. Thomson also pivots his armature with its axis vertical, and spins it like one of his gyrostats. Unfortunately, the machine has not shown itself to be in practice a success. Its construction necessitates a very high speed, else the electromotive force would be small. If the radial bars, instead of being all joined to one rim, were united by overlapping insulated rims, each one to the one next to that diametrically opposite, and a connection brought round again at the hub to the next but one from that at which the outer rim started, then, applying similar connections all round, the radii would all be connected in circuit, and a much higher electromotive force might be obtained. I am not aware that any disk so connected has yet been tried.

Some improvements have also been made in the Elphinstone-Vincent machine. The sections of the armature of this machine are wound separately in parallelogram forms like that shown in Fig. 29, and the separate sections are then fixed upon the periphery of a papier-mache cylinder, which is mounted so as to rotate between powerful field-magnets and internal field-magnets whose poles re-enforce the field. In the improved machines the parallelograms of wire are so arranged that the overlapping ends lie outside the ends of the polar surfaces of the field-magnets, which, therefore, can be brought very close to the surface of the rotating cylinder. Among other improvements, also, segments of the collector are internally cross-connected, so that only two brushes are needed instead of six as formerly. Several improvements in mechanical details have also been made.

In alternate current machines something has also been done. The Ferranti-Thomson machine, which, at the date of my Cantor lectures, had just made its appearance, has been considerably perfected. By the courtesy of Mr. Hammond, I am enabled to show Figs. 30 to 33, illustrative of the "1,000-light" dynamo, and of its working parts. Externally, the machine is scarcely changed at all; the driving pulley being a little larger in proportion. Internally, considerable changes have been made, and in these the hand of the experienced mechanical engineer is apparent. The frame-work of the machine is now cast in two halves, which are afterward bolted together. Fig. 31 shows one-half of the carcass of the machine with its projecting circle of magnet cores, C, which receive the field-magnet coils. The armature, originally a single zigzag piece of copper, has assumed the form shown in Fig. 32, in which it may be seen that the convolutions are multiplied, and are held in their places by bolts through a star-shaped piece of brass, which also serves to carry to one of the two collectors the connection with one of the zigzag copper strips. There are in fact three complete circuits of copper strips in the armature connected in parallel arc. They begin at three of the alternate four bolts of the star-shaped piece, and, folding round one another, they all eventually unite with a second and inner star-shaped piece, which communicates with the second collector. Each strip makes ten turns round the zigzags, so that there are thirty layers, all well insulated from one another by strips of vulcanized fiber. This armature is 30 in. in diameter, and a little more than ½ in. thick in the upper convolutions, so that the opposite poles of the field-magnets can be brought very close together, and a very powerful field produced. The entire armature weighs only 96 pounds. The most extraordinary part of the machine is, however, the arrangement adopted for conveying the currents to the external circuit. The axle carries on either side of the armature an insulated collector ring of bronze, to which the aforementioned star-shaped pieces are respectively connected. Instead of brushes, solid pieces of metal shown at C′ C′, Fig. 33, are employed to collect the current. These collectors hook on over the collecting rings, and bear against about 180° of the periphery of each ring. They are fixed on universal joints, and held by springs from rotating. Copper strips connect them to the terminals of the machine. The arrangements for lubricating the bearings are extremely perfect. The machine requires a speed of 1,400, and weighs 1½ tons. Mr. Ferranti has also designed a slow-speed dynamo to run at 300 revolutions per minute, and feed 500 lamps.

A very large alternate current machine was shown at the late Electrical Exhibition at Vienna, by Messrs. Ganz, of Buda-Pesth. It was capable of furnishing light for 1,200 Swan lamps (20 candle-power each). This dynamo, which in some points resembled Gordon's well known machine, was constructed according to the Mechwart-Zippernowsky system. The thirty-six bobbins of the field-magnet were set concentrically on an iron frame, and rotated within an outer circle of thirty-six armature bobbins. The field-magnet coils were, in fact, the fly-wheel of the high-pressure compound engine which drove the machine and its exciter. The diameter of the rotating part was 2½ meters. A salient feature of this machine is the fact that any one of the coils, either of armature or field-magnets, can be removed from the side of the machine, in case such are needed. The whole fly-wheel can, in this way, be taken down by one man in a few minutes. An electrical efficiency of 85 per cent. is claimed for this machine.

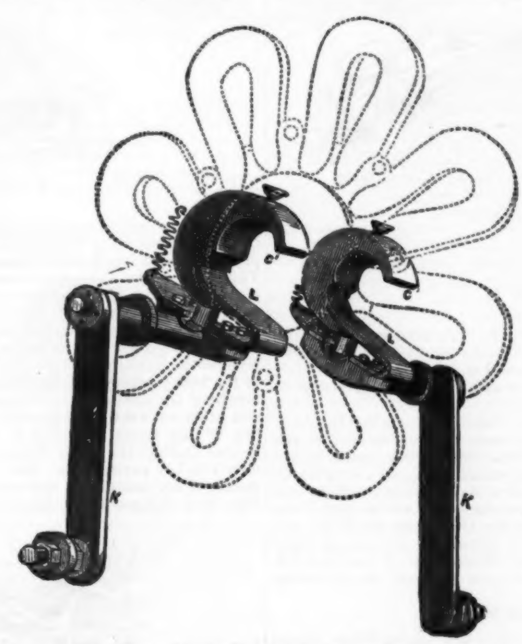


FIG. 33.—COLLECTORS OF FERRANTI DYNAMO.

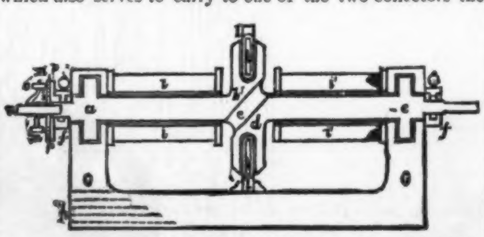


FIG. 34.—SIR C. BRIGHT'S SUGGESTED DYNAMO.

Of one other class of machines—the unipolar dynamo—I had intended to say something. It is a remarkable thing that, though to my knowledge a great deal of attention has been paid lately to machines of this type, no one has yet succeeded in designing a practical unipolar dynamo. There seems to be some hiatus in the theory of this class of machine, for the very singular fact remains that those which are designed in defiance of precautions to avoid wasteful internal eddy currents will work, though badly, and those designed with such precautions will hardly work at all.

There are two or three other new designs for machines which, at present, can hardly be called anything but curiosities. There is, for example, a design for a dynamo (a drawing of which is given in Fig. 34), by Sir Charles Bright, in which the field-magnet coils and armature stand still, but in which the iron cores and the brushes rotate. There is another design by Professor G. Forbes, in which part of the field-magnets rotate. Mr. C. Lever has designed a machine on somewhat similar principles to the foregoing. I have myself essayed an alternate-current machine, in which both armature and field-magnets stand still, while laminated pole-pieces alone revolve. I hear also of a dynamo designed in the States in which there are no field-magnets, only two revolving armatures.

And now I have left myself no time to deal with the third branch of my subject, namely, the dynamo in its functions as a mechanical motor. In this branch also much progress has been made. If time permitted, I would speak of the motors designed by Professors Ayrton and Perry, which are successful to a very remarkable degree in yielding a great mechanical power in proportion to their weight. I might have been inclined to say something of the attempts made by the same able electricians to produce a self-governing motor by various devices of centrifugal and periodic governors, and also by using an ingenious differential winding. I might tell you how I have myself worked at the question from a different point of view, and have sought to govern motors so that they shall run at a uniform speed, by devices which will not wait until the speed changes before they act, but by devices depending upon the variations in the lead of the machine, in short, upon dynamometric governors instead of centrifugal ones. These things must, however, wait until some more convenient season. Time will only admit of my showing you here, in conclusion, a model designed by Mr. C. Dorman to illustrate the graphic law of efficiency of motors, which I put forward in my Cantor lectures, and which I am happy to learn has since been largely used in many different countries.

To sum up, then, it may be observed that in every department under review, the story of the past fifteen months is one of solid progress. It has been, it is true, progress of a quiet and perhaps of a commercial rather than a scientific order, yet, as I have shown you, one in which practice and theory have gone hand in hand. Is it true that in some few points theory is ahead of practice, but in a still larger number practice is ahead of theory. It would be a great boon to us if our theoreticians could bring up theory to the level of practice in some of the simplest facts. We do not even know the exact law of the saturation of iron in electro-magnets, and content ourselves with formulæ which we *know* to be incorrect. Of the laws of induction of magnetism in circuits partly consisting of iron, partly of strata of air, or of copper wire, we know very little. We want some new philosopher to do for the magnetic circuit what Dr. Ohm did

for the voltaic circuit fifty years ago. There is ample room for progress yet in theory as well as in practice; and the perfection of theory means the deliverance of practice from arbitrary rules of thumb, and from the blunders of inexperience which have so retarded progress in the past. The history of the past fifteen months, however, gives great encouragement for the future, because it shows how much may be done, even in the face of great commercial depression, by those whose knowledge and experience give them a deliberate faith in the future, and whose efforts are directed toward no uncertain end. A steady development toward the yet far distant goal of perfection is going on unceasingly. The progress of which I am permitted to be the chronicler to-night is progress of the good and substantial kind, that owes nothing to the excited rush of Stock Exchange speculations, and which, not having been nurtured at an unhealthy fever heat, is destined to be of permanent value.

THE HONEY ANTS OF THE GARDEN OF THE GODS.

OF the various kinds of ants known, one genus in particular—*Myrmecocystus*—has specially attracted the attention of naturalists from the fact that one of its castes or worker forms presents the peculiarity of having the abdomen distended to the size of a currant or small grape, and entirely

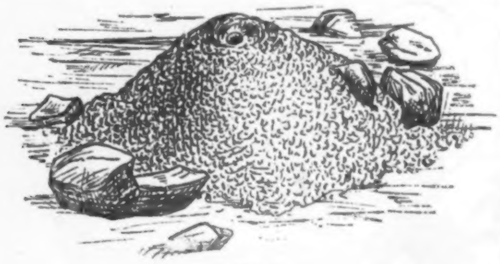


FIG 1.

filled with grape sugar or "honey." As comparatively little had been ascertained in regard to the habits of these insects, the Rev. Henry C. McCook was led, in July, 1879, to start for New Mexico, in order to make a thorough study of them.

During a brief visit to Gen. Charles Adams, of Manitou, Colorado, whose residence is located at the mouth of the Garden of the Gods, Mr. McCook, while making some observations upon the ants in the vicinity, opened a nest which proved to his delight to be that of the very ant which he had set out to study. He therefore abandoned his projected trip to New Mexico, encamped in the Garden of the Gods, and began a series of observations. From the account of these which he has published in the *Proceedings* of the Philadelphia Academy of Natural Sciences, we make the following abstract:

ARCHITECTURE.

Externally, the nests of the honey ant consist of low, gravel covered moundlets, penetrated at the center by a tubular

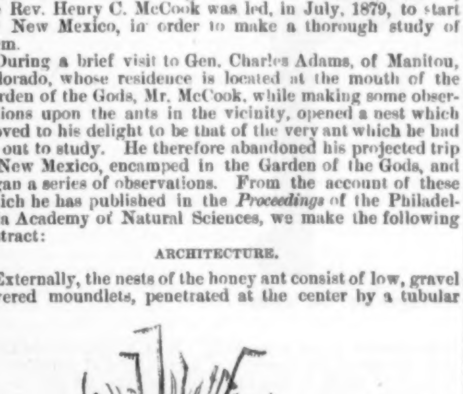


FIG. 2.

gallery or gate, three-fourths of an inch in diameter (Figs. 1 and 2). The gate or structure nearest the entrance is a single tubular opening, which is smooth within, and which penetrates the mound and the earth perpendicularly to a depth that varies from 3½ to 6 inches. It is funnel shaped at the top, and the funnel is gravel lined. The nozzle descends perpendicularly or with a slight slope for about 3 inches, and then deflects at a more or less abrupt angle, forming an arm (Fig. 3, A), usually shorter than the nozzle. This leads into a series of radiating galleries and rooms, and the point of deflection may be called the vestibule (V). These galleries usually extend chiefly in one direction from the gate. There are, indeed, galleries immediately surrounding the gate on every side, but these appear to be limited, except in one direction, within a radius of about 8 to 10 inches, and to the same distance in depth. These general statements are illustrated by Figs. 3, 4, 5, and 6, which represent sections of four nests, which may be considered typical of all. The last

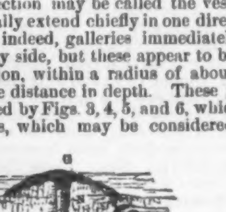


FIG. 3.

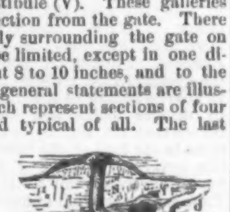


FIG. 4.

named figure gives an idea of the relation of some of the honey rooms to the gate and the upper series of galleries. These honey rooms lie at least as near to the surface as 6 or 8 inches. They vary in size, but, for the most part, are about 5 or 6 inches in length and 3 or 4 in width. They are irregular in outline, but have a general tendency toward the oval. One of the most irregular is shown at H R in Fig. 7. The floors and walls are smooth, some of them quite so. The ceiling, on the contrary, is rough, and thus greatly favors the use to which the honey bearers put it as a perch.

The galleries are tubular openings that vary somewhat in size from one-half to three-fourths of an inch or more in diameter. The underground formicary may be described in general terms as a system of galleries and rooms arranged in several horizontal stories, one above another, approximating the order of "stories" in a house, and intercommunicating at many points by vertical galleries.

In one of the formicaries examined (shown in horizontal and vertical sections in Figs. 9 and 10), the series of galleries and honey rooms terminated in a single gallery (Fig 8, *g, g, g*) about 18 inches long, ⅜ inch wide, and ¼ inch deep. The gallery sloped sharply with the slope of the hillside on which the nest was made. Near the middle part thereof was the queen room, C. Besides the queen, the room contained a large number of naked grubs, callows, honey bearers, and workers. Ten inches below the queen room, the gallery, *g, g, g*, was continued until it finally terminated in a small circular chamber or bay, E, on the one side, and on the opposite in a narrow gallery, *tg*, which curved upward. This was the end of the formicary.

POSITION OF HONEY BEARERS IN THE NEST.

In the first nest that was opened the gravel had not been penetrated to a depth of more than 6 inches before a honey chamber was uncovered (Fig. 11). Within a dome shaped vault, about 3 inches in width and ¾ to 1 inch in height, hung the honey bearers, clinging by their feet to the ceiling.

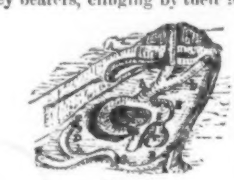


FIG. 5.

Their yellow bodies stretched along the ceiling, but the rotund abdomens hung down, almost perfect globules of transparent tissue through which the amber colored honey showed. They looked like a cluster of small Delaware grapes or large currants. Most of the abdomens were quite round, but they were in various stages of fullness. A few, especially those that were but little distended, were of a white instead of amber color. When the abdomen is full, it fairly shines, and reflects the light that falls upon it from a lamp. With most of the honey bearers the abdomens hang downward without touching the ceiling, except at the rotundity near the base, and often not even at that point. As before stated, the ceiling of the honey chamber is rough. This character, of course, enables the honey bearer to cling more easily and securely to her perch. She does not hold this position by means of her mandibles, but almost exclusively by her feet. The fully charged bearers are not much disposed to change

FIG. 6.

their roost after once taking it, at least after they have reached a considerable degree of rotundity. Yet they are capable of moving their position, and occasionally do so. If once they loosen their hold, however, and fall to the floor, they seem ordinarily helpless to recover, and, as a rule, remain helplessly stationary, and so pass their lives. These unfortunates are faithfully attended, and are often cleansed and caressed, but the workers never seem to attempt to right them and restore them to the ceiling. Moreover, when a portion of the roof chances to fall and bury a bearer, no effort is made by the workers to extricate her from her uncomfortable position.

SOURCE OF HONEY SUPPLY.

The rotunds do not elaborate their honey, as has been frequently asserted, but are charged by regurgitation from the

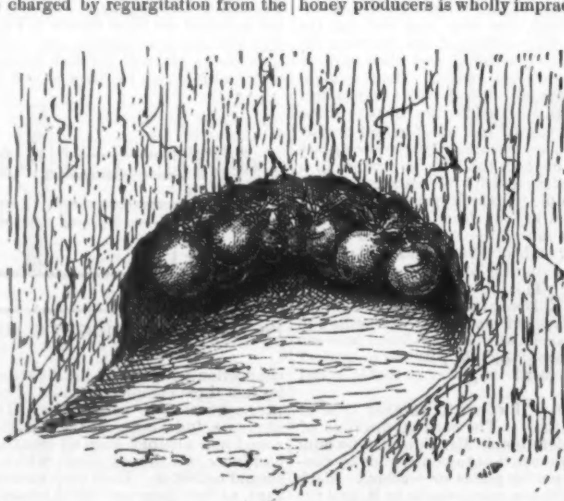


FIG. 11.

workers, which have normal abdomens, and are the honey gatherers. But whence do the latter obtain their supply? In his efforts to determine this Mr. McCook soon discovered that these ants were nocturnal insects, their nests being as silent, and to all appearances as empty, as an abandoned habitation during the daytime. After patiently watching the column as it left the nest after nightfall, and following it for several evenings, he finally discovered its objective point to be a species of oak (*Quercus undulata* var.). Arriving here, the ants were observed to move about among clusters of brownish red galls, to which they frequently applied their mouth organs. The dimness of the light and the distance which Mr. McCook was obliged to keep prevented him from seeing anything more than this. But it was plain that they were obtaining honey stores, since by the lantern light it could be seen that their abdomens were already much distended by the sweets which they had lapped. Directing his attention to the galls, it was seen that some of them were gradually exuding minute globules of a white, transparent liquid, which the ants greedily licked. Mr. McCook tasted the liquor, and found that it was very sweet and pleasant. The object of the nocturnal expedition of the ants and the source of their honey supply were thus revealed.

Observations daily repeated upon a number of nests determined that the ants leave their dwellings for the oak thickets at or near 7:30 o'clock P.M., and between that hour and 8 o'clock, which is about the time of sunset in July and August. Previous to the departure, the crater, gate, and exterior of the mound become gradually covered with swarms of insects, whose yellow bodies quite hide the red gravel surface of the nest. There always remains a very numerous force at home, which is seen at all hours of the night on

FIG. 7.

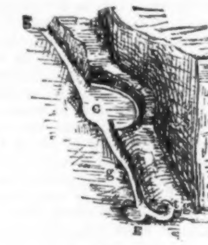


FIG. 8.

guard within and around the gate. The return home begins about or a little before midnight, and continues until between four and five. Numbers of workers patrol the mound and vicinity, challenging nearly all incomers, who have to stand the test and give the required satisfaction by means of the antennal password. None of the returning repletes is tolled by these home sentries.

QUALITY OF THE HONEY.

The honey is very pleasant, and has a peculiar aromatic flavor suggestive of bee honey. It is slightly acid in summer

FIG. 9.

from a trace of formic acid that it contains, but is perfectly neutral in autumn and winter. It has been found upon analysis to be a nearly pure solution of sugar of fruits (glucose), which, in a state of hydration, is isomeric with grape sugar ($C_{12}H_{14}O_{14}$), and differs therefrom in not crystallizing.

The uses to which the Mexicans and Indians put this ant honey are various. That they eat it freely, and regard it as a delicate morsel, is beyond doubt. Prof. Cope, when in New Mexico, had the ants offered to him upon a dish as a dainty relish. The Mexicans press the insects, and use the gathered honey at their meals. They also are said to prepare from it by fermentation an alcoholic liquor. Again, they are said to apply the honey to bruised and swollen limbs, ascribing to it great healing properties. Dr. Loew's suggestion to bee keepers to test the commercial value of these ants as honey producers is wholly impracticable. The difficulties of farming the colonies, gathering the supply, and the limited quantity of the product would prevent a profitable industry. The greatest number of honey bearers in a large colony, taking Mr. McCook's observations as a standard, will not exceed 600, which, counting 6 grains of honey to the ant, would be little more than one-half pound avoirdupois. Besides, the sentiment against the use of honey thus taken from living insects, which is worthy of all respect, would not be overcome. The Mexicans and Indians will therefore probably not be disturbed in their monopoly of the honey product of the nests of this ant.

QUEEN LIFE.

After the usual custom of ants, the queen is continually surrounded by a guard of workers (Fig. 12), which vary in numbers, but which are usually twelve or twenty. These attendants quite inclose her and restrict her movements, and apparently watch and guard her with great carefulness. Upon one occasion, noted by Mr. McCook, when she escaped to the upper surface of the nest, she was followed and seized by a worker major, who interlocked her mandibles with the queen's and dragged her down the gateway into the interior.

During the process of ovipositing, she is surrounded by a number of workers of all castes, some of whom lick her abdomen, especially beneath and at the apex. One, meanwhile, gives her food in the usual way, that is, by regurgitation. When the queen moves, a dwarf seizes a fore foot and attempts to control her course. This, and nipping with the mandibles, is the common mode by which the guard directs the queen's motions. When the queen accidentally places a foot upon the egg mass, a dwarf seizes the foot hastily and draws it back, while another worker catches up the egg mass and draws it aside.

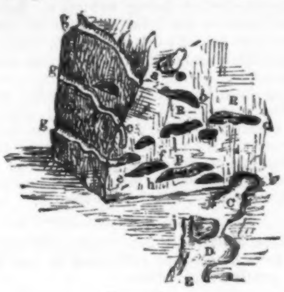


FIG. 10.

CLEANSING AND FEEDING LARVÆ.

The solicitude of the workers for the helpless larvæ is a matter for admiration. The offices of nurse do not seem to be confined to any one caste, but the burden of duty appears to be assumed by the dwarfs, and next to them by the minors. When the grub is to be cleansed, it is taken in the mouth, turned by the fore pair of legs, the antennæ meanwhile touching and apparently aiding, while the mandibles are applied over the grub, their teeth apparently working chiefly within the annular divisions of the several joints. Doubtless this motion is accompanied by a free use of the tongue. When the grubs are to be fed, the workers pass from one to another, striding over them, and standing among them (Fig. 13), as they lie in little groups. The wee white things peck up their brownish yellow heads, which they stretch out and move around as if soliciting food. Their nurses move from one to another, apply the mouth for a moment, and pass on.

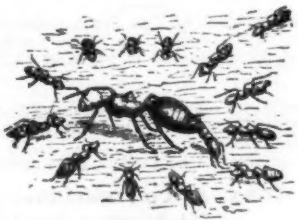


FIG. 12.

FIG. 13.

At the slightest alarm, the grubs are seized and hurried into the recesses of the nest.

ECONOMY OF THE HONEY BEARERS.

From studies made upon artificial formicaries, from structure, and from reasonable analogy, Mr. McCook has no hesitation in saying that the economy of the remarkable structure and habit presented by the honey bearer is precisely that of the bee in storing honey within the comb. The difference lies in the fact that the bee puts her store within inorganic, and the ant within organic matter; the bee within a waxen cell, and the ant within the living tissues of her sister formicarian. The queen, the virgin females, the males, and the teeming nursery of white grubs are all and always altogether dependent upon others for nurture. During the winter months and in seasons when the honey supply is scant or wholly fails, the entire family must have food. Precisely as the bee goes to the honey comb in such emergencies, the honey ant goes to the honey bearer. There is, to be sure, a corresponding difference in the mode of eliciting the stored up sweets. The hungry ant places her mouth to that of the bearer, from whose mouth it is received as it is regurgitated from the honey crop. The muscles of the abdomen act upon that organ as does the pressure of a lady's hand upon the bulb of a vaporizer. It is forced up, gathers into a little globule upon the filament-like maxillæ under the jaw, whence it is lapped off by the waiting pensioners. The act of receiving supplies from the honey bearer was witnessed by Mr. McCook soon after he had transferred some ants to an artificial nest. The rotund threw her head up, raised her thorax, and regurgitated a large drop of amber fluid which hung upon the mouth and palps. At first, two ants were feeding—a major, who was in a position similar to that of the rotund, and a dwarf, who stood upon her hind legs and reached up from below. During the feeding, another major was attracted to the banquet, and obtained her share by reaching over the back of the first worker, indeed partly standing upon her, and thrusting her mouth into the "common dish" (Fig. 14). The mandibles and maxillæ of the pensioners serve as a sort of dish, upon which a particle of honey is taken and is afterward licked off more at leisure.

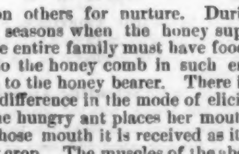


FIG. 14.

The fondness of the workers for the store within the rotunds was strikingly shown during the excavation of a nest. Necessarily, in breaking down the rooms, the distended abdomens of some of the honey bearers were ruptured. The high state of excitement which pervaded the colony, the ordinary instinct to defend the nest and preserve the larvæ, cocoons, and other dependents, were at once suspended in the presence of this delicious temptation, and amid the ruins of their home the workers paused, clustered in large groups around the unfortunate comrade, and greedily lapped the sweets from the honey moistened spot.

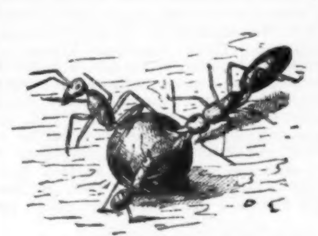


FIG. 15.

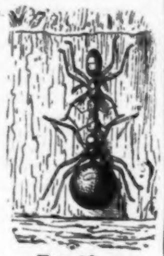


FIG. 16.

TREATMENT OF THE DEAD ROTUNDS.

From time to time the honey bearers die. The bodies of those which perish upon their perch usually hang from the ceiling for days before the death grip finally relaxes and they fall. During Mr. McCook's observations it happened more than once that the workers failed to perceive the change, and for some time—a day or more—after death, continued to cleanse and tend the defunct with the accustomed solicitude. When the fact was at last perceived, and the dead removed, the round abdomen was first severed from the thorax by clipping the petiole, then the parts were separately removed to the "cemetery," that common dumping ground for the dead, which these ants, like all others, invariably maintained. In view of the fact last recorded, it seemed curious that the stored treasures of these "honey pots" were not secured by cutting the sealing tissue. In point of fact, this was never seen to be done, and the amber globes were pulled up galleries, rolled along rooms, and bowled into the graveyard along with the juiceless legs, heads, and other members. They were never once deliberately opened, in spite of their tempting contents. If this act were the result of an instinctive sentiment by which Nature guarantees protection to the living honey bearer (and this, indeed, is likely), it must seem to us very beautiful and praiseworthy. But what if it were only the consequence of a mentalism so low and fixed within its instinctive ruts as to hinder even a suggestion of utilizing the wasting store by opening the abdomen?

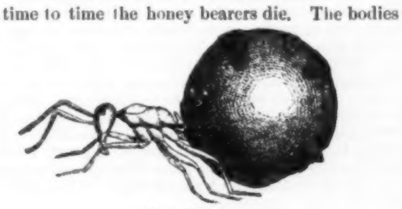


FIG. 17.

FIG. 18.

ACTS OF BENEFICENCE.

In the natural sites the workers showed great interest in the preservation and removal of the rotunds, dealing with them very much as with the larvæ. As the honey rooms were opened and the rotunds disturbed from their roosts, the workers of all castes rushed eagerly to them and dragged them into the unbroken interiors. Sometimes several ants would join in removing one rotund, pushing and pulling her along. One sketch (Fig. 15), made in Mr. McCook's notes, represents a major pulling a rotund, whom she has seized with her mandibles by the outer abdominal wall, while a dwarf worker is mounted upon the globe, standing upon her hind legs "a-tiptoe," as it were, pushing lustily. Another sketch (Fig. 16), caught on the spot, represents a worker major dragging a rotund honey bearer up the perpendicular face of a cutting made in the excavation of the nest. The mandibles of the two insects were interlocked, and the worker *backed* up the steep, successfully drawing her protege.

This interest is maintained in the daily life of the formicary. The workers were continually seen hovering about the rotunds as they hung from the roof of my nests, or as they lay upon the floor cleansing their bodies. It is evident that these creatures are regarded as dependents, and, as with the queen, virgin females, males, and larvæ, are fed and tended by the active members of the community. In all these cases the same communal instinct would, of course, control action, giving at least the semblance of beneficence.

FIG. 19.

FIG. 20.

But a great number of examples fell under notice which go to throw doubt upon the possession of any personal or individual sentiment as toward special cases of need, outside of the above limit.

In making up his artificial nests, Mr. McCook first packed down the soil and then introduced the ants, knowing that they would work out their own habitations. The honey bearers were thus mingled upon the surface with the workers, upon whom fell the entire task of digging. In this work and in the distribution of the excavated pellets, there was much room for the exhibition of indidividual carefulness and tenderness toward the honey bearers; but not a single instance of the kind was noted, while the exhibitions of apparent cruel neglect and positive cruelty were numerous. When the bearers became partially buried in various uncomfortable positions, heads downward, bodies awry, etc., the workers would pass by and over them continually for many days, without the slightest concern, and certainly without a single observed effort to relieve their comrades, who could readily have been extricated and drawn into the chambers.

DESTRUCTION OF THE ANTS BY MITES.

The untimely end of Mr. McCook's artificial colonies is worthy of a passing note. The ants were brought from Colorado in large jars, domiciled in their native soil. Every precaution was taken to keep them in health, but after a confinement of over seven months, they became infested with mites, the germs of which had probably been brought from Colorado with the insects. Mr. McCook was powerless to help the sufferers free themselves from their destroyers, and was obliged to stand by and see the victims yield up life to the parasitic swarm that was sucking at their vital juices. The parasites literally covered the mouth parts, where they were chiefly congregated, although they were also attached to other parts of the body. The cemetery at one side of the formicary gained many inmates daily; the galleries and chambers, thinned of their busy populace, grew lonely, and at last the dead were suffered to lie where they fell, for the living were themselves sealed to death and unable to give their comrades sepulcher. So our author's nests faded away, until, unwilling longer to witness suffering, he gave all the remaining insects a painless death.

FIG. 22.

FIG. 23.

The Colorado insects, upon which Mr. McCook's studies were based, he regards as a new variety of *Myrmecocystus melliger*, and he has accordingly named it *var. hortus deorum*. Figs. 17 and 18 are lateral and dorsal views of the honey bearer of this species, magnified three diameters. Figs. 19

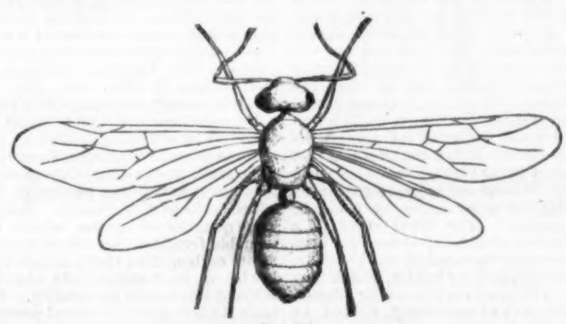


FIG. 21.

and 20 represent males of the same variety, × 5. Figs. 21 and 22, winged female or virgin queen of the same, × 3. Fig. 23 shows a worker minor of the same, ×5. The workers major and minor, or dwarf, are exactly similar in form.

THE INDIANS OF NEW MEXICO.

When Fernando Cortez, in 1519, landed his eleven ships and 617 men near what is now Vera Cruz, and, according to the legend, "burning his ships behind him," so there could be no retreat, with his ten small field pieces, thirteen muskets all told, and numerous other arms, marched upon the city of Mexico, he found the native people about as far advanced in civilization as the ancient Romans were at the close of the republic, or perhaps as the Basques of his own native Spain were in his own time. This civilization, it was found, extended in a manner up the western side of the continent, west of the Cordillera and Sierra Madre Mountains, the dividing ridge between the Atlantic and the Pacific systems of rivers, about as far north as the latitude of what is now San Francisco, but gradually becoming less in going north, and finally merging into nomadic savage life in the far Northwest. In fact, there was a Mexican tradition, at the time, to the effect that their Aztec civilization had originally come from the sturdy, vigorous north, though present studies of the subject rather militate to the theory that it was wafted up the coast with the high isothermal line that bounded it by the genial breezes that came from the tropics and the homes of similar races in tropical lands.

In 1537, about a dozen years after Cortez had mastered Mexico, one of his officers named Cabeza de Vaca went on an exploring expedition up the western coast and into the western part of what is now New Mexico of our United States, and there, west of the Sierra Madres, on the headwaters of what is now known as the Gila River, he found several semi-civilized tribes settled and living in villages, to whom he applied the general term "pueblos," signifying in Spanish the *people* and their *towns*—about equivalent to our word *populations* or *communities*. He conveyed the first authentic account of these villages to the Mexican capital, though there were already vague traditions there of the "Seven Cities of Cibola" somewhere in the north, and in 1540 an expedition was fitted out under a Spanish officer named Coronado to make a further exploration to search particularly for the famed seven cities, and to subjugate to the Spanish-Mexican authority these and any such peoples as might be found. Coronado spent a couple of years trying to reduce these pueblos to subjection, and then without any satisfactory success abandoned the undertaking and returned to the capital. As the Spanish power increased in extent and strength, however, the pueblos were eventually subdued in 1586, and their country made a part of the empire. But they threw off the Spanish yoke in 1680 and restored their own patriarchal form of government, under which they still live without being disturbed, though embraced in the territory ceded by Mexico to the United States in 1847.

There are now in this semi-civilized district, as far as known, about nineteen pueblos, containing in all about 8,400 inhabitants. The largest and most important pueblo is Zuni, situated on a knoll on the bank of Zuni River, an inconsiderable stream, one of the sources of Salt River, a tributary of the Gila River, just mentioned, which upper system flows through the pueblo country, and converging in the Gila empties into the Colorado River near its entrance into the head of the Gulf of California, thus suggestively connecting this seat of aboriginal civilization by water, and a sort of umbilical cord, with the cosmopolitan and semi-tropical waters of the Pacific Ocean. The present site of Zuni is about two miles from a high ridge, or "meza," upon the top of which are the ruins of ancient Zuni, concerning which there is a tradition among the Zunians that the town was once removed, in a manner, from its present site to the top of Meza, on account of a great flood which deluged the country, and that after the waters had been propitiated by the sacrifice of two children they subsided, permitting the villagers to occupy the present site again. Besides these ancient ruins there are, among others less prominent, the ancient ruins of Jemez, which though like those of Zuni located higher than the modern town, are not celebrated by the same tradition. It is likely that war and peace had more to do with these changes of altitude than a deluge and its subsidence, for some of the modern towns are built on the summit of high mezas, and are extremely difficult of approach. The plans of the town and houses are substantially the same throughout the district. The houses are sometimes built of stone, but generally of adobe, sun-dried brick, as in old Mexico, and are always several stories high, usually from three to five. Each story occupies a smaller area than the one below, thus leaving a terrace or walk around the base of each, and evidently so built for defensive purposes, while at the same time the terraces answer the purpose of balconies and convenient lounging places for the people. The roofs and the floors, which are about the same thing in construction, are generally formed by frames of rafters or joists filled in with willow brush, and the whole covered with clay plastered on water tight, or sometimes in the case of floors with a flagging stone. The house is sometimes the town and the town the house, that is, the whole town, substantially, is in one extensive house, or block. In such cases there is generally a hollow square or court around which the series of apartments are built, though sometimes the whole is a compact mass of rooms in the form of a pyramid six to eight stories high without any court. In each pueblo there are large rooms sometimes underground for religious observances or councils, and called in Spanish "estufas." The lower story of a house is seldom occupied by the people, but is used for lumber purposes, and has doors easily barricaded, on the inside. The only access to the upper stories is by ladder, which may be drawn up at pleasure. The rooms are generally plastered, or washed, rather, with a sort of white clay, lighted by windows, formerly of sheets of mica and now sometimes with glass, and are ordinarily quite dry, light, and comfortable.

Modern Zuni is supposed, from all accounts, to have at one time contained a population as high as 5,000, but the United States census of 1880 shows remaining only 1,602. Still it is the metropolis of the region. The tribe next in size and importance to the Zunians are the Moquis, numbering altogether about 1,500, and living in several villages southwest of Zuni farther down the water courses and nearer the sea, as if they had been the original pioneers and propagators of their peculiar civilization. In keeping with this theory, their villages particularly are built on the summits of mezas from 400 to 600 feet high. Coronado called their province Tusayan, which name it still bears. Their principal pueblos are Tewa and Oraybi. The other tribes are the Toltos in Taos, the Jemez of the pueblo of Jemez, and the Pojuaque, which latter tribe now numbers only thirty or forty persons.

These tribes are evidently all of the same origin, of about the same degree of civilization, similar in customs and habits, and versed in the same occupations. It is hard now to define just what effect the early Spanish civilization may have had upon them, but they were found by the first Spaniards that came to the country, like the Southern Mexicans, already living in houses and towns, cultivating the soil and practicing the useful arts, and when first coming under the knowledge and jurisdiction of the United States were found about the same as they are now. While they live in their fortified towns, so to speak, in war times, in winter they have their little farms lying about through the country, with temporary summer dwellings on them, which they occupy mostly during the planting and harvesting seasons. They raise grain, vegetables, cotton, squashes, melons, peaches, etc., and have flocks of sheep and goats. They and their aboriginal civilization remind one of the ancient Aryans of the Hindoo Koos Mountains and valleys, the first agricultural race of history and the founders of the Indo-European civilizations and languages. These American Aryans, or Aztecs, as they are called, while naturally shy and exclusive on account of the nature of their surroundings for centuries past, are, when assured of good intentions, peaceable, gentle, kind-hearted, and hospitable. While favored on the west to the Pacific with the neighborship of peaceful tribes similar to their own, they are bordered on the north, east, and south by the warlike Navajos and Apaches, with whom they have to exercise all their tact to keep at peace. In fact, in New Mexico and Southern Colorado the Pueblos are called the "Quaker Indians."

The Moquis are perhaps the leaders of civilization among the pueblo Indians. While among all these pueblo tribes the men do the hardest farm work, and while all are temperate, industrious, and virtuous, the Moqui women, particularly, excel in such work as knitting, spinning, weaving, and making fine blankets, women's robes, and other fancy articles for sale to the neighboring wild tribes, and now as curiosities to the whites. By the way, the Navajos on the north of the pueblos make the same kind of blankets, even of a superior quality, which among other things would tend to show some old as yet unsolved relationship between these wild and these semi-civilized tribes. The pueblo men dress similarly to the more southern Mexicans, while the women usually wear a sort of tunic and a shoulder blanket or shawl. The married women wear their hair rolled up on the back of their head, while the maidens exercise their taste and indicate their single blessedness by gathering their raven tresses up in a sort of bunch or rosette over each ear. With all their aboriginal civilization there is yet a recognizable difference between the belles of the pueblos and those of New York and Boston, though as an illustration of a great fundamental, homogeneous principle, the most attractive of the one may be more attractive than the least attractive of the other.—*N. Y. Graphic.*

CULTURE OF RASPBERRIES.

David W. King of Cayuga County, N. Y., who has 22 acres of small fruits in the southwestern part of the county, and whose crops of raspberries and blackberries are among the heaviest we have ever seen, adopts the following course of management: First, the land is well underdrained, and since this operation was performed, his plants are free from rust, which before draining was quite prevalent. Manure, at the rate of ten loads to the acre, is scattered between the rows in autumn, which serves both as a winter mulching and for enriching the land, and for which course manure answers well. Six bushels of salt and twenty bushels of unleached wood ashes are sown broadcast in the spring, and plowed in very shallow as early as the ground will work mellow. This operation cuts off all the suckers; the furrows are first turned from the rows, and then back toward them, and they are cultivated level once a week till the last of June. His crop of blackberries was smaller the past season on account of the injury to the canes the previous winter, being only 101 bushels per acre. The previous year, by a careful measuring of the land twice, and keeping a record of the sales, a part of the land was found to yield 180 bushels per acre. His crop of Gregg raspberries gave about 100 bushels per acre the past season.—*Country Gentleman.*

COMPOSITION OF MANURE.

The value of manure depends not only upon the character of the feed allowed, but also upon the condition of the animal, the breed, and the age. The principal substances of value in manure are nitrogen, phosphoric acid, and potash, the former substance being the most costly. In the artificial fertilizers, nitrogen exists in the shape of sulphate of ammonia, nitrate of soda, or as Peruvian guano, while ground dried blood, leather, and other substances containing it are sometimes used. Potash is usually supplied in the form of the sulphate (kainit) or muriate, its quality depending upon the grade of the salt used for the purpose, while the phosphoric acid (usually combined with lime) is derived from bones and sometimes from guano deposits and marine formations. The Carolina phosphate beds have been largely instrumental in cheapening this article, while that from bones is usually associated with proportions of nitrogen.

Barnyard manure and artificial fertilizers differ only in form. The active ingredients of barnyard manure are the same as those in fertilizers, excepting that the manure contains small proportions of magnesia, soda, and a few other substances not always present in fertilizers, though easily added to them if necessary. Manure contains, however, a large quantity of carbon, which is considered by some a valuable fertilizer, but others contend that as plants appropriate carbon from the atmosphere through the agency of the leaves, such matter only adds to the bulk of the manure without improving the quality. When food is fed to animals it undergoes a chemical process in the body, which extracts the nutritive portions for sustenance, according to the digestive capacity of the animal, the residuum being voided as being no longer useful in that respect.

The amount of available fertilizing material in the manure thus voided depends upon the character of the food, and its relative proportions of nitrogen, which is always costly. As growing animals require not only food for warmth, but for growth also, the manure from such is less in value than from animals that are matured. And as more food is required to assist the body against cold winter than for any other purpose, the warmth of the quarters is a factor in the matter also, especially if it be correct that carbon is beneficial as a manure to the roots of plants.

Assuming that animals are well fed on average quality of food, then, for every 1,000 pounds of manure from horses, more than 700 pounds consist of water, while the remainder is estimated at about twelve pounds of phosphoric acid, twenty-eight pounds of potash, and five pounds of ammonia. The manure from the cow contains nearly 860 pounds of water in every 1,000, the amount of phosphoric acid in the remainder being about five pounds, potash ten pounds, and nitrogen three pounds, the manure from the horse being double the value of that from the cow in all the substances except nitrogen, and even in nitrogen the horse manure is nearly twice as rich. Of the different kinds of manure, that from fowls and the human species is the richest in nitrogen, but this includes the urine, the solid portions being very deficient in that respect. Manure from the sheep is the richest in phosphoric acid. Urine is always rich in ammonia (nitrogen), with proportions of potash and small quantities of phosphoric acid. Considering this fact, too much importance cannot be given the saving of liquids, that from the human species being valued at half a cent per pound. The value of the solid portions of manure from a horse for one year is said to be about $10, while the value of the liquids from the same source for the same period is nearly the same.

Considering the high value of the liquids, which are always immediately available as plant food when applied to the soil, the manure must be protected from drenching rains and melting snows, for as part of the inert matter of the manure is changed by chemical action in the heap during the process of decomposition into soluble matter, it is always lost unless protected.—*Philadelphia Record.*

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